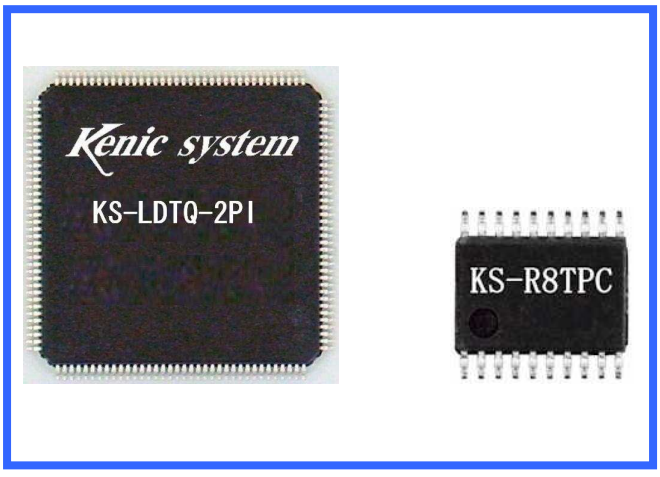
LCD Controller IC

KS-LDTQ-2PI

Hardware Manual

September 2011, First Edition



(Note) Silk screen print in the above picture is a composite. The actual print may differ.

● Introduction ●

First of all, thank you for having purchased our LCD controller IC (KS-LDTQ-2PI) and the touch panel controller IC (KS-R8TPC) (the "Product"). This hardware manual (the "Manual") provides an overview of the Product. We hope that you will read the Manual carefully and make use of it for efficient development.

● Important Information ●

1. The Product and this Manual may change without notice. Before using the Product, obtain the newest catalog, manual, etc., from the company website.
2. The Product is not designed to be used in systems or devices that can cause death, injury, or serious physical or environmental damage directly due to any malfunction of the Product (life support device, nuclear facility equipment, aircraft, traffic control equipment, various safety devices, etc.). Danger and damage due to the Product being used in the foregoing systems or devices are the sole responsibility of the customer.
3. We assume no responsibility for any damages due to the use or the operation of the Product in a misguided or wrongful way.
4. The usage examples outlined herein are only an explanation of the Product functions. We assume no responsibility for any complaints, accidents, or any disadvantages which may be caused by the use on the basis of the examples outlined in this Manual.

Table of Contents

1. Composition of the LCD Controller IC and the Touch Panel Controller

1) KS-LDTQ-2PI (LCD controller IC)

KS-LDTQ-2PI can control the following LCD: color TFT LCD "LMTM057QVGNCA series" (manufacturer: DENSITRON), and color TFT LCD "GVTQ57NPAD series" (manufacturer: SGD).

2) KS-R8TPC (Touch panel controller)

KS-R8TPC is a CPU device with 2 channels, 8-bit A/D conversion (manufacturer: Renesas, model: R5F211B4SP).

(Manufacturer of the CPU and product number may change without notice.)

LCD display and touch panel control become possible by using the above set of two. Additionally, display is also possible using only the LCD controller IC.

2. Overview and Features of the Product

KS-LDTQ-2PI is an LCD controller developed for embedded systems, with the following characteristics.

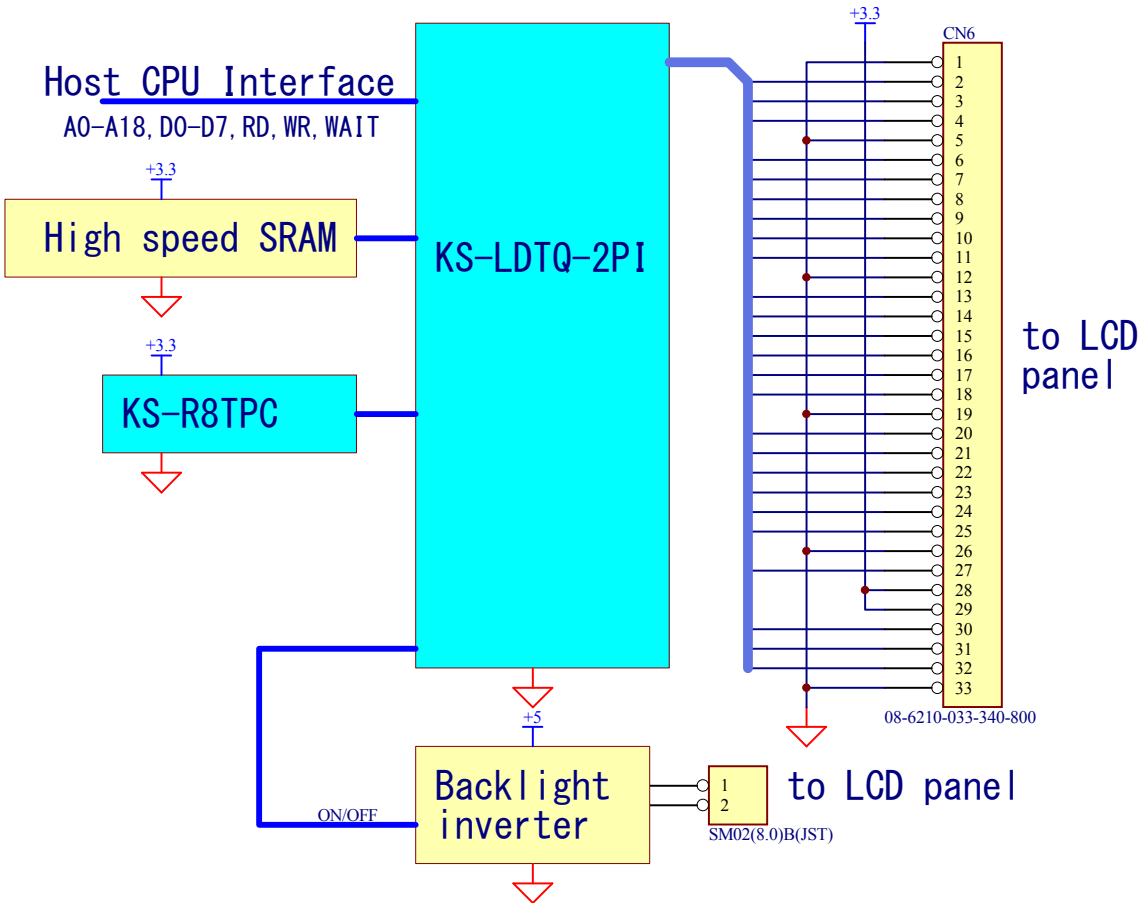
1) As palette format is used, it can display 64 colors in 4,096 colors×2 pages.
2) By making the screen one page, 65,000 colors can be displayed. (There are function restrictions such as blinking, etc.).
3) Dot number is 320×240 dots.
4) There is an automatic switch display function per dot, which decreases the load on the CPU.
5) There is a Hard Fill function that fills in a page immediately in a specified color.
6) Design is easy with only knowledge of the Host-CPU. LCD expertise is not necessary.
7) Two external analog signals are automatically obtained in 8-bit. Therefore, the temperature sensor and the touch panel can be connected by minimum circuit configuration.
8) The Host-CPU is most compatible with the H8 Host-CPU (Hitachi) and SH Host-CPU. (Interface with 3.3V Host-CPU is possible.)
9) The circuit design is extremely simple. Refer also to the attached circuits.
10) Due to the direct connection to the address bus, the LCD controller appears to

be SRAM from the Host-CPU.

11) A PWM output port is provided. This signal can be used to control dimming for the LED backlight power supply.

12) An INTOUT output port is provided. After completion of the hard fill, the active LOW signal is outputted. By connecting to the IRQ port of the CPU, the hard fill completion can be detected with interruption.

The outline framework for KS-LDTQ-2PI is as follows. The customer only needs to prepare a high-speed SRAM circuit in order to complete the LCD controller.
In this Manual, we have provided the reference circuits as examples. (However, operation of these circuits is not guaranteed. Be aware that the circuit may not operate due to certain circumstances and conditions.)



Note 1. The aqua-colored areas indicate the LCD controller and the touch panel controller.

The following table indicates pin assignments (list of pin numbers and signal names) for KS-LDTQ-2PI.

Table 1) KS-LDTQ-2PI

Pin No	Pin Name	Interface	Pin No	Pin Name	Interface
1	A17	Generic Host-CPU address bus	73	G5	To LCD panel
2	A16		74	G4	
3	A15		75	G3	
4	A14		76	G2	
5	A13		77	G1	
6	A12		78	G0	
7	A11		79	R5	
8	A10		80	R4	
9	A9		81	R3	
10	VCCIO3	+3.3V	82	VCCIO1	+3.3V
11	GNDIO3	0V	83	GNDIO1	0V
12	A8	Generic Host-CPU address bus	84	R2	To LCD panel
13	A7		85	R1	
14	A6		86	R0	
15	A5		87	Hsync	
16	GND	0V	88	GND	0V
17	A4	Generic Host-CPU address bus	89	Vsync	To LCD panel
18	A3		90	DCLK	
19	A2		91	MD0	High speed SRAM data bus
20	A1		92	MD1	
21	VCC	+3.3V	93	VCC	+3.3V
22	A0	Generic Host-CPU	94	MD2	High speed SRAM data bus
23	WAIT		95	MD3	
24	RD		96	MD4	
25	WRL		97	MD5	
26	VCCIO3	+3.3V	98	VCCIO1	+3.3V
27	GNDIO3	0V	99	GNDIO1	0V
28	SEL0	Generic Host-CPU	100	MD6	High speed SRAM data bus
29	SPARE	No connection	101	MD7	
30	D7	Generic Host-CPU data bus	102	MD8 (*1)	
31	D6		103	MD9 (*1)	
32	D5		104	MD10 (*1)	
33	D4		105	MD11 (*1)	
34	D3		106	MD12 (*1)	
35	D2		107	MD13 (*1)	
36	D1		108	MD14 (*1)	
37	GNDIO2	0V	109	MD15 (*1)	
38	VCCIO2	+3.3V	110	MUB (*1)	High speed SRAM address bus
39	TMS	Signal for configuration	111	SPARE	No connection
40	D0	Generic Host-CPU data bus	112	MLB	High speed SRAM address bus
41	SPARE	No connection	113	MOE	
42	TCK	Signal for configuration 4.7kΩ pull-down	114	SPARE	No connection
43	SPARE	No connection	115	MA0	High speed SRAM address bus
44	SPARE		116	MA1	
45	SPARE		117	VCCIO0	+3.3V
46	SPARE		118	GNDIO0	0V
47	TDO	Signal for configuration	119	MA2	High speed SRAM address bus
48	SPARE	No connection	120	MA3	

49	SPARE		121	MA4	
50	SPARE		122	MA5	
51	TDI	Signal for configuration	123	GND	0V
52	VCC	+3.3V	124	MA6	High speed SRAM address bus
53	VCCAUX	+3.3V	125	MA7	
54	PWM	To backlight part	126	MA8	
55	CLK	Clock etc.	127	MA9	
56	PCLK	To KS-R8TPC	128	VCCAUX	+3.3V
57	PDATA		129	VCC	+3.3V
58	TPV		130	MA10	High speed SRAM address bus
59	GND	0V	131	MA11	
60	BLEN	To backlight part	132	MA12	
61	U/D	To LCD panel	133	MA13	
62	R/L		134	MA14	
63	VCCIO2	+3.3V	135	VCCIO0	+3.3V
64	GNDIO2	0V	136	GNDIO0	0V
65	ENAB	To LCD panel	137	MA15	High speed SRAM address bus
66	B5		138	MA16	
67	B4		139	MA17	
68	B3		140	MA18	
69	B2		141	INTOUT	Interrupt request output
70	SLEEP	Pull-up	142	RESET	Reset circuit
71	B1	To LCD panel	143	SPARE	No connection
72	B0		144	A18 (*2)	High speed SRAM address bus

Precautions

(*1) The KS-LDTQ-2PI does not use these signals (MD15~MD8, MUB) is not used. Use the open state.

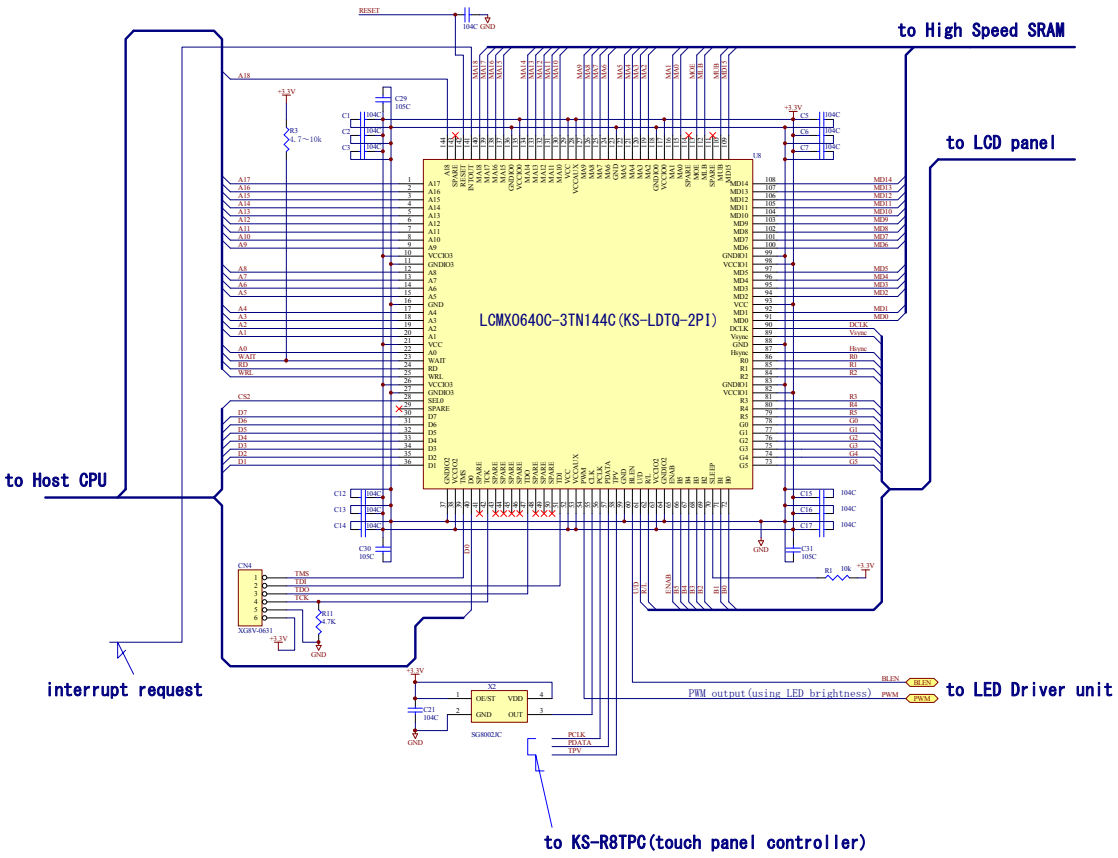
(*2) The KS-LDTQ-2PI can be also used in the open state.

Table 2) KS-R8TPC

1	P3-5	YD	11	P1-6	YOUT
2	P3-7	TPV	12	P1-5	PDATA
3	RESET	Reset IC etc.	13	P1-4	PCLK
4	XOUT/P4-7	Clock 10MHz	14	P1-3	XIN
5	VSS/AVSS	GND	15	P1-2	LED etc.
6	XIN/P4-6	Clock 10MHz	16	AVCC/VREF	+3.3V
7	VCC	+3.3V	17	P1-1	Touch panel input YU
8	MODE	Pull-up	18	P1-0	Touch panel input XL
9	P4-5	Pull-up	19	P3-3	XOUT
10	P1-7	YIN	20	P3-4	XD

【Reference Circuits】

(1) Reference Circuit Diagram of the LCD Controller IC Area



(Connection and Precautions)

- Quartz Module

  Although the quartz module contains the SG8002 (EPSON); any product of the following clock speed can be used for each LCD controller.

  KS-LDTQ-2PI (QVGA-TFT): 49.0909MHz

Kenic system

- CPU Bus

  Connect to H8 Host-CPU (Hitachi), SH Host-CPU, etc. Always pull up with a resistance of 4.7k~10k for the WAIT signal.

- Reset Signal

  The LCD controller provides RESET# input pins for the LCD controller. The internal circuit is reset by ACTIVE LOW. Connect the reset signal used by the CPU, etc. Additionally, if there is noise on the reset signal line, mount a capacitor with the capacity of about 104 near the RESET# input pin, in order to prevent inadvertent resets.

- Connection to the High Speed SRAM

  Refer to "(2) Reference Circuit of the High Speed SRAM" below.

- Connection to the LCD

  Refer to "(3) Reference Circuit of the LCD I/F" below.

- Connection to the LED Backlight Circuit

  Refer to "(4) Reference Circuit for Backlight I/F" below.

- Connection to the Touch Panel Controller (KS-R8TPC)

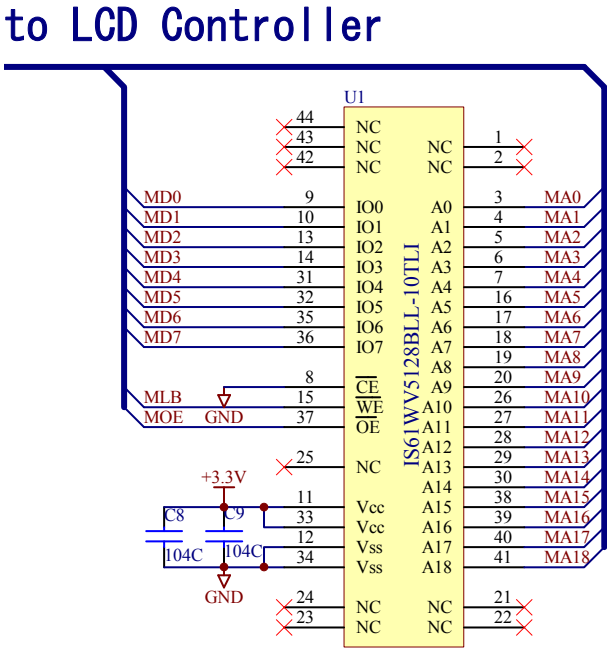
  Connect control signals (PCLK, PDATA, TPV) as shown in "(5) Connection Example to KS-R8TPC" below.

  When using the LCD controller only, use with the open state.

- Arrangement of the Bypass Capacitor

  Be particularly careful about the arrangement of the bypass capacitor. When a four- layer board is impossible, bring as close to the LSI VCC pin as possible.

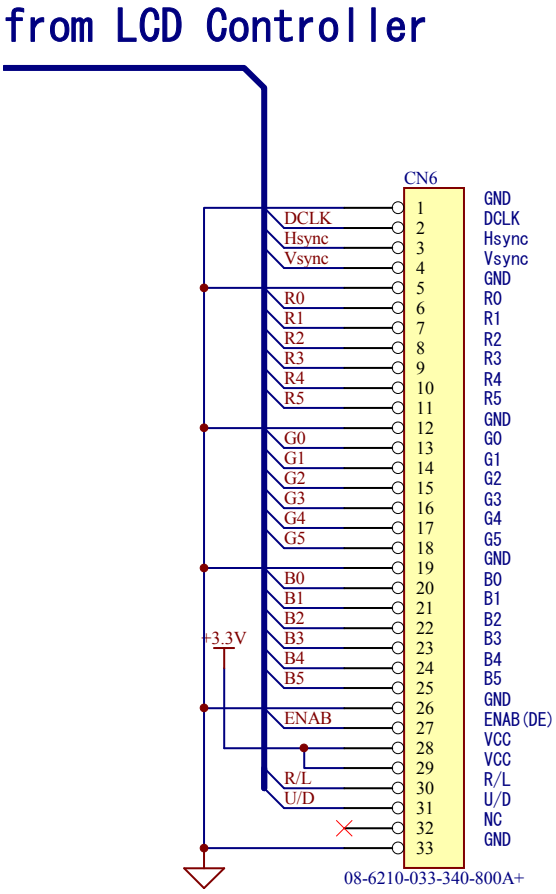
(2) Reference Circuit of the High Speed SRAM (IS61WV5128BLL-10TLI)



As in the circuit diagram above, simply connect to the chipset KS-LDTQ-2PI as signal name. In any of the above cases, be careful with the connection of the bypass capacitor; place near the VCC. Additionally, for the pattern length, make sure the distance from the KS-LDTQ-2PI is under 10cm (under 5cm is recommended). The high speed SRAM is compatible with 12nS products, but use one that is 10nS and under where possible.

(3) Reference Circuit of the LCD I/F

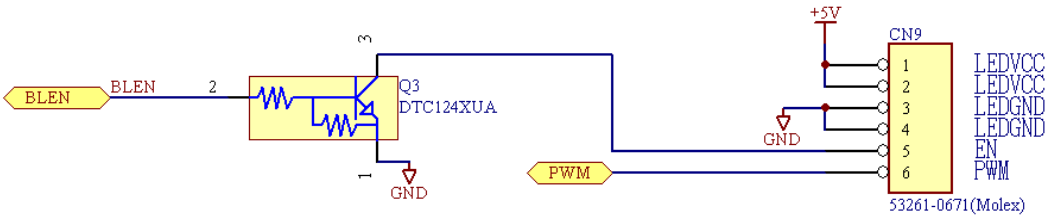
・Connection example to GVTQ57NPAD series (SGD)



The above diagram is the reference circuit diagram when connecting GVTQ series (Densitron) LCD to KS-LDTQ-2PI.

(4) Reference Circuit for Backlight I/F (reference)

・Reference circuit for LED backlight (Kenic System: KSLBC-3 (D2))



The above diagram is an example connection between the LED backlight power supply "KSLBC-3(D2)" (Kenic system) (sold separately) and the LCD controller.

When the EN signal is open, the backlight is in the ON state. By connecting the BLEN signal outputted from the LCD controller to the open collector or digital transducer, ON/OFF for the backlight can be controlled.

Brightness of the backlight can be controlled by the PWM signal. The PWM frequency range is 100Hz~1000Hz. The PWM frequency can be selected by the register setting. For the setting method, refer to "PWM Frequency Switching Register" in "7. About the Registers".

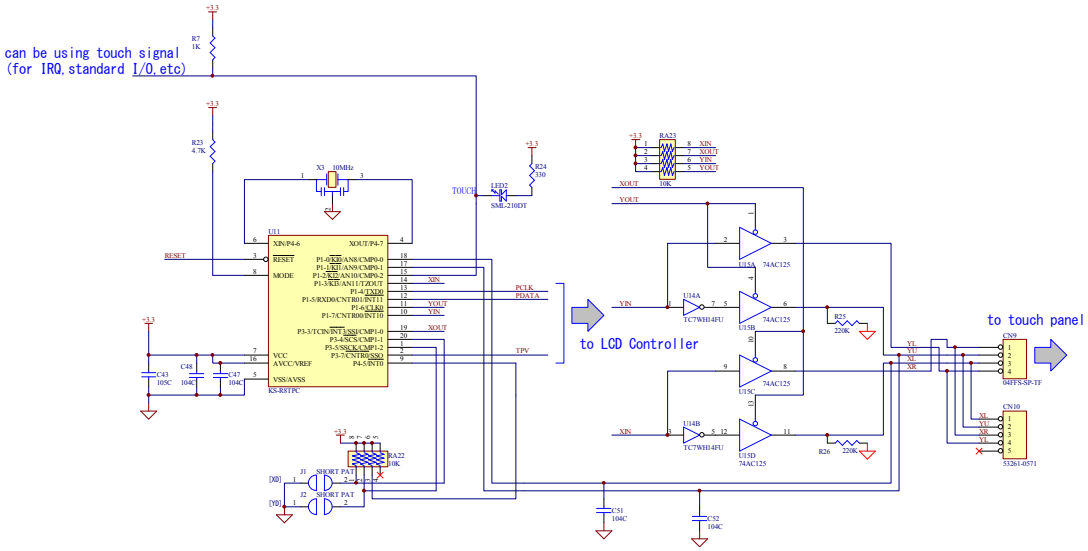
(5) Connection Example to KS-R8TPC and the Touch Panel

Compatible Touch Panels

(1) G22-6D (Gunze)

(2) ATP-057 (DMC)

(3) Others (Most analog touch panels are supported.)



(Connection and Precautions)

・ Connection to LCD controller IC

Connect the control signals (PCLK, PDATA, TPV) as shown in "(1) Reference Circuit Diagram of the LCD Controller IC Area" above.

・ Reset signal

The touch panel controller internals are initialized by ACTIVE LOW.

・ Jumper XD and YD

When shorting jumper XD, the X axis data of the touch panel is reversed. When shorting jumper YD, the Y axis data of the touch panel is reversed.

With this setting, it is possible to match the display orientation and the touch panel data orientation.

・ Other

When the touch panel is pressed, the TOUCH signal outputs a low signal. The LED can be turned on, and, by connecting to the CPU's IRQ interrupt port, pressing of the touch panel can be detected by interruption.

3. Electrical Characteristics and Specifications

1) KS-LDTQ-2PI

● Maximum Ratings

Item	Sign	Rating	Units
Power supply voltage	V_{CC}	-0.5～3.75	V
Power supply voltage	VCC AUX	-0.5～3.75	V
Output power supply voltage	VCC IO	-0.5～3.75	V
Added I/O tri-state voltage		-0.5～3.75	V
Added input exclusive pin voltage		-0.5～4.25	V
Storage temperature	T_{STG}	-65～+150	℃
Junction temperature	T_j	+125	℃

● Recommended Operating Conditions

Item	Sign	Min.	Max.	Units
Internal core power supply voltage	V_{CC}	1.71	3.465	V
Auxiliary power supply voltage	VCC AUX	3.135	3.465	V
I/O driver power supply voltage	VCC IO	3.135	3.465	V
Junction temperature	Tj	-40	100	℃
Ambient Operating temperature	Ta	-20	80	℃

The LCD controller contains a built-in core power supply.

Therefore, it can operate at 3.3V single supply.

● DC Standard

Item	Sign	Min.	Max.	Units
Input Hi voltage	V_{IH}	2.0	3.6	V
Input Low voltage	V_{IL}	-0.3	0.8	V
Output Hi voltage	V_{OH}	VCCIO -0.4		V
Output Low voltage	V_{OL}		0.4	V

● Approximate Current and Power Consumption

LCD Controller		KS-LDTQ-2PI		
Item	Sign	Standard	Max	Units
Approximate power consumption	POWER	149.5	330.5	mW
Approximate current consumption	ICC	45.3	100.2	mA

● Refresh Rate

LCD Controller		KS-LDTQ-2PI	
Item	Sign	Standard	Units
Refresh rate		57	Hz

2) KS-R8TPC

● Maximum Ratings

Item	Sign	Rating	Units
Power supply voltage	V_{CC}	-0.3～6.5	V
Analog power supply voltage	AV_{CC}	-0.3～6.5	V
Input voltage	V_{IN}	-0.3～V_{CC}+0.3	V
Operating temperature	T_{OPR}	-20～85	℃
Storage temperature	T_{STG}	-65～150	℃

● Recommended Operating Conditions

Item	Sign	Min.	Standard	Max.	Units
Power supply voltage	V_{CC}	2.7	—	5.5	V
Analog power supply voltage	AV_{CC}		Vcc=Avcc		V

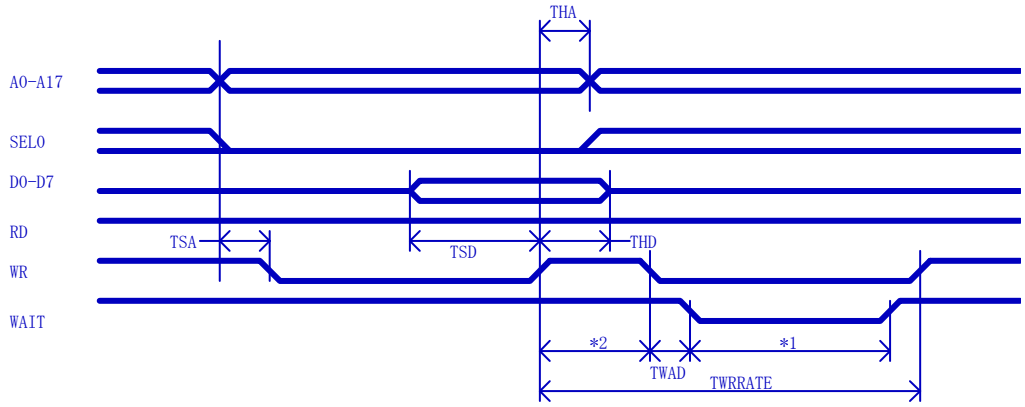
$AV_{CC}=V_{CC}$

● DC Standard

Item	Sign	Min.	Max.	Units
Input Hi voltage	V_{IH}	0.8 V_{CC}	V_{CC}	V
Input Low voltage	V_{IL}	0	0.2 V_{CC}	V
Output Hi voltage	V_{OH}	V_{CC}-0.5	V_{CC}	V
Output Low voltage	V_{OL}		0.5	V

For more details, refer to the CPU device data sheet (Manufacturer: Renesas).
The data sheet can be downloaded from the manufacturer's website.

3) Write Cycle for the LCD Controller Host-CPU Interface

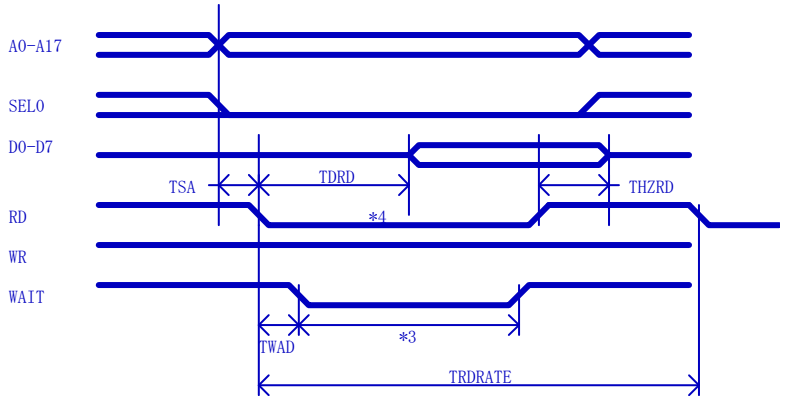


LCD Controller		KS-LDTQ-2PI		
Sign	Item	Min.	Max.	Unit
TSA	Address setup	10	—	ns
THA	Address hold	10	—	ns
TSD	Data setup	5	—	ns
THD	Data hold	10	—	ns
TWAD	WAIT output delay	—	12	ns
*1	WAIT width	—	130	ns
*2	Write interval	150	—	ns
TWRRATE	Write rate	155	—	ns

*1 WAIT is triggered when the next data write occurs within the “WAIT width” following the first data.

*2 WAIT signal can be ignored when writing at intervals the same or longer than the “write interval” value.

4) Read Cycle for the LCD Controller Host-CPU Interface



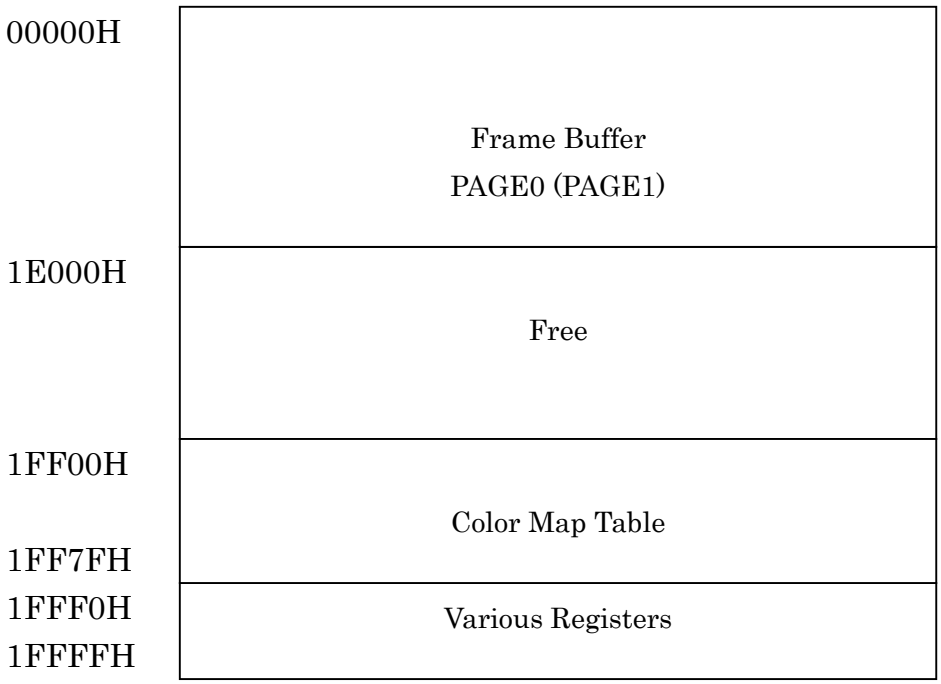
LCD Controller		KS-LDTQ-2PI		
Sign	Item	Min.	Max.	Unit
TSA	Address setup	10	—	ns
TDRD	Read access	—	220	ns
THZRD	The time indicates that data output comes to Hi impedance from the reactive of read.	—	10	ns
TWAD	WAIT output delay	—	15	ns
*3	WAIT width	—	250	ns
*4	RD pulse width	260	—	ns
TRDRATE	Read rate	330	—	ns

*3 As the WAIT signal is always sent when the RD pulse is under “WAIT width”, connect the WAIT signal to the CPU, when using.

*4 WAIT signal can be ignored when the RD pulse of the CPU is the same or longer than the “RD pulse width”.

4. Address Map

【KS-LDTQ-2PI】



The above is the address map for the LCD controller. The frame buffer has area for 2 pages (PAGE0 and PAGE1).
The bank switching method is used to switch PAGE0 and PAGE1, and this is accomplished by setting control register 2 (DCR2). Therefore, the address range of the frame buffer as viewed from the CPU is one screen.

5. Dot Composition of the Screen

(0, 0)=0000H,	(1, 0)=0001H	…	…	(319, 0)=013FH
(0, 1)=0200H,	(1, 1)=0201H	…	…	(319, 1)=033FH
(0, 2)=0400H,	(1, 2)=0401H	…	…	(319, 2)=053FH
(0, 239)=1DE00H,	(1, 239)=1DE01H	…	…	(319, 239)=1DF3FH

Each dot corresponds completely to each bit.
For this LCD controller, the next address 0140H after the end of the first line (319, 0) = 0013FH corresponds to (320, 0) and not (0, 1), and continues to (511, 0) = 01FFH. Therefore, the frame buffer exists from (0, 0) to (511, 239). However, the displayable area is limited to the range from (0, 0) to (319, 239).

6. Displayed Data

This LCD controller uses the color palette format. Firstly, the following is an explanation of this color palette format.

【About the color palette】

When displaying color, usually the color code is designated; for example, there are times when this color code is fixed, such as 02H for blue, 0CH for green, however, another method is when the value of 02H is not fixed to a color such as red but instead indicates that a value representing a color is being stored at that location. With this way, programmers can code more abstract software.

As such, the register housing the list of color addresses and the colors themselves is called the "color palette table."

For example, let's suppose the command "draw a BOX from (100, 100) to (200, 200) using color 03H" is written in the C language. The color indicated by 03H is at first aqua, but let's also say that afterwards we want to change the color to light green. In this case, we only have to change the color registered to 03H in the color palette, and the areas drawn using 03H will all change automatically. Even when the LCD can display only 64 colors, it is possible to select from 4,096 colors, allowing for a remarkably better visual quality.

(1) 64 Colors in 4,096 Color Mode

The display data to be written to each frame buffer need to have a set color palette code.

Image Memory Area

00000H~1DFFFH

Bit	7	6	5	4	3	2	1	0
Name	M1	M0	P5	P4	P3	P2	P1	P0
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Initial value	-	-	-	-	-	-	-	-

(Caution) Initial value is indefinite.

Dot Control Bit　bits 7~6

M1	M0	Explanation
0	0	Normal display.
0	1	Transmission display.
1	0	Blink 1.
1	1	Blink 2.

(Caution)　These M1 and M0 bits function as part of a set with control register 1 (DCR).

Color Palette Table　bits 5~0

P5	P4	P4	P2	P1	P0	Explanation
0	0	0	0	0	0	The data housed in color map table 0~63 is displayed in advance.
0	0	0	0	0	1	
1	1	1	1	1	0	
1	1	1	1	1	1	

For the method to house color data for each color palette, refer to the "About the Registers" chapter.

(3)　65,536 Color Mode

When setting a two-layer, superimposed display for DCR1 and setting a write page for DCR2, the background side is the higher order bit and the foreground side is the lower order bit, for a total of 16-bits (R, G, B).

Background Side　bits 7~0

Bit	7	6	5	4	3	2	1	0
Name	R4	R3	R2	R1	R0	G5	G4	G3
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Initial value	-	-	-	-	-	-	-	-

Foreground Side　bits 7~0

Bit	7	6	5	4	3	2	1	0
Name	G2	G1	G0	B4	B3	B2	B1	B0
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Initial value	-	-	-	-	-	-	-	-

7. About the Registers

(1) Register for the Color Palette

Addresses 1FF00H~1FF7FH

There are 64 color palettes, and each can be set as 12-bit (4,096 colors). The palette number must be set for drawing.

Color Palette Address List

Bit order	b7	b6	b5	b4	b3	b2	b1	b0	b7	b6	b5	b4	b3	b2	b1	b0
Color data format	-	-	-	-	R3	R2	R1	R0	G3	G2	G1	G0	B3	B2	B1	B0
Palette 0	1FF01H								1FF00H							
Palette 1	1FF03H								1FF02H							
Palette 2	1FF05H								1FF04H							
. . . .																
Palette 61	1FF7BH								1FF7AH							
Palette 62	1FF7DH								1FF7CH							
Palette 63	1FF7FH								1FF7EH							

Example) Color Palette 63

Address 1FF7EH (Even Address G, B)

Bit	*7*	*6*	*5*	*4*	*3*	*2*	*1*	*0*
Name	*G3*	*G2*	*G1*	*G0*	*B3*	*B2*	*B1*	*B0*
R/W	*W*	*W*	*W*	*W*	*W*	*W*	*W*	*W*
Initial value	-	-	-	-	-	-	-	-

Address 1FF7FH (Odd Address R)

Bit	*7*	*6*	*5*	*4*	*3*	*2*	*1*	*0*
Name					*R3*	*R2*	*R1*	*R0*
R/W	*W*	*W*	*W*	*W*	*W*	*W*	*W*	*W*
Initial value	-	-	-	-	-	-	-	-

(2) PWM Frequency Switching Register

Address 1FFF7H (Write side)

Bit	7	6	5	4	3	2	1	0
Name	-	-	-	-	-	-	PFSEL1	PFSEL0
R/W	W	W	W	W	W	W	W	W
Initial value	0	0	0	0	0	0	1	1

This register is for switching the PWM frequency of the LED backlight power supply. The default PWM frequency is 0.375 kHz and corresponds to the LED backlight power supply "KSLBC-3 (D2)" (Kenic system). When using the LED backlight power supply "KSLBC-2" (Kenic system), set the PWM frequency to 95.88 kHz.

Bits 1~0

PFSEL1	PFSEL0	Explanation
0	0	PWM frequency 95.88kHz
0	1	PWM frequency 1.498kHz
1	0	PWM frequency 0.749kHz
1	1	PWM frequency 0.375kHz (default)

(Note) When clock input for the LCD controller is 49.0909 MHz, the frequency values are as above.

(3) Control Register 1 (DCR1)

Address 1FFFCH (Write side)

Bit	7	6	5	4	3	2	1	0
Name	MODE	BLK2	BLK1	PEE	BK1	BK0	FR1	FR0
R/W	W	W	W	W	W	W	W	W
Initial value	0	0	0	0	0	0	0	0

DCR1 sets the foreground/background of the frame buffer (2 pages), controls transmission display, controls Blink 1 and 2, and controls ON/OFF display.

Bit 7

MODE	Explanation
0	64 colors in 4,096 color mode.
1	65,536 color mode.

Bits 6~5

BLK2	BLK1	Explanation
0		Blink 2 inactive.
1		Blink 2 active.
	0	Blink 1 inactive.
	1	Blink 1 active.

(Note) Blink 2 can blink at a higher speed than blink 1.
Blinking cycle for each LCD controller is as follows.

Blink 1 blinking cycle ・・・ About 1 second
Blink 2 blinking cycle ・・・ About 0.5 second

Bit 4

PEE	Explanation
0	Transmission display inactive.
1	Transmission display active.

(Caution) Only 4,096 color mode.

Bits 3~2

BK1	BK0	Explanation
0	0	The background page is Page 0.
0	1	The background page is Page 1.
1	0	Inactive setting.
1	1	Inactive setting.

Bits 1~0

FR1	FR0	Explanation
0	0	The foreground page is Page 0.
0	1	The foreground page is Page 1.
1	0	Inactive setting.
1	1	Inactive setting.

Address 1FFFCH (ADX) (Read)

Bit	7	6	5	4	3	2	1	0
Name	ADB7	ADB6	ADB5	ADB4	ADB3	ADB2	ADB1	ADB0
R/W	R	R	R	R	R	R	R	R
Initial value	-	-	-	-	-	-	-	-

KS-R8TPC has an 8-bit A/D conversion function; this conversion result is received by KS-LDTQ-2PI and housed to the register automatically. Sampling speed is continuously performed at around 5mS~8mS, and read from the above register is always possible. With this function, an interface without excessive hardware (analog joystick, analog touch panel, or other analog sensors) is possible.

(4) Control Register 2 (DCR2)

Address 1FFFDH (Write side)

Bit	7	6	5	4	3	2	1	0
Name	-	-	PEE1	PEE0	RFB1	RFB0	WFB1	WFB0
R/W	W	W	W	W	W	W	W	W
Initial value	0	0	0	0	0	0	0	0

DCR2 sets the write page and the read page for the frame buffer (2 pages), sets the frame buffer page for performing hard fill, etc.
In addition, when performing hard fill, set the page number of the

frame buffer performing hard fill (designate with PEE1, 0-Bit) and write page number (designate with WFB1, 0-Bit) to the same page.

Bits 5~4

PEE1	PEE0	Explanation
0	0	The page of the frame buffer performing hard fill is set to page 0.
0	1	The page of the frame buffer performing hard fill is set to page 1.
1	0	Inactive setting.
1	1	Inactive setting.

Bits 3~2

RFB1	RFB0	Explanation
0	0	Read page is set to page 0.
0	1	Read page is set to page 1.
1	0	Inactive setting.
1	1	Inactive setting.

Bits 1~0

WFB1	WFB0	Explanation
0	0	Write page is set to page 0.
0	1	Write page is set to page 1.
1	0	Inactive setting.
1	1	Inactive setting.

Address LCTQ=1FFFDH (ADY) (Read side)

Bit	7	6	5	4	3	2	1	0
Name	ADB7	ADB6	ADB5	ADB4	ADB3	ADB2	ADB1	ADB0
R/W	R	R	R	R	R	R	R	R
Initial value	-	-	-	-	-	-	-	-

The function of the register is like control register 1 and can also read A/D conversion results.

(5) Brightness Control Register of the LED Backlight (DCR4)

Brightness of the LED backlight is controlled by the PWM output. By changing the ON width of the PWM in the register, the brightness can be set.

Address 1FFF9H

Bit	7	6	5	4	3	2	1	0
Name		CT6	CT5	CT4	CT3	CT2	CT1	CT0
R/W	-	W	W	W	W	W	W	W
Initial value	-	1	1	1	1	1	1	1

The default is 7FH (Duty 100%). When using the LED backlight power supply "KSLBC-3(D2)" (Kenic system), the brightness is at a maximum. However, please note that when using the LED backlight power supply "KSLBC-2" (Kenic system), the brightness is at a minimum. For maximum brightness with "KSLBC-2", set 00H.

(6) Control Register 3 (DCR3)

Address 1FFFBH (Write side)

Bit	7	6	5	4	3	2	1	0
Name	-	-	-	-	-	U/D	R/L	BLI
R/W	-	-	-	-	-	W	W	W
Initial value	-	-	-	-	-	1	0	1

DCR3 performs display control for the LCD.

Bits 2~1 Controls the display orientation.

For GVTQ57NPAD series (DENSITRON) displays, when looking at the LCD with the flat cable coming out from the left, the display orientations are as follows.

Register Setting Value		Display Switching Signal		Display orientation
U/D	R/L	U/D	R/L	
1	0	1	0	Normal display.
1	1	1	1	Flip horizontal.
0	1	0	1	Half-turn.
0	0	0	0	Flip vertical.

U/D=1, R/L=0	U/D=1, R/L=1	U/D=0, R/L=1	U/D=0, R/L=0
			

The U/D and R/L values in the diagram are register setting values.

(Caution) Depending on the type and model of the LCD, the display orientation settings may differ. Always check the LCD specifications before setting the display orientation.

Bit 0

BLI	Explanation
0	Backlight off
1	Backlight on

(7) Data Register for Hard Fill (CFDR)

Address 1FFFEH

Bit	7	6	5	4	3	2	1	0
Name	M1	M0	P5	P4	P3	P2	P1	P0
R/W	W	W	W	W	W	W	W	W
Initial value	0	0	0	0	0	0	0	0

This is the same as the data for drawing. By setting a palette number to this register, the register can quickly fill one page worth of the frame buffer with the same data.

(8) Hard Fill Command Register (CFCR)

Address 1FFFFH

Bit	7	6	5	4	3	2	1	0
Name	-	-	-	-	-	-	-	BUSY
R/W	-	-	-	-	-	-	-	R/W
Initial value	-	-	-	-	-	-	-	0

With the palette number housed in the CFDR, color data from the color palette register is selected, and the data is used to fill the frame buffer

for the page set in the PEE bit of DCR2.
To implement, simply write any data to the register.

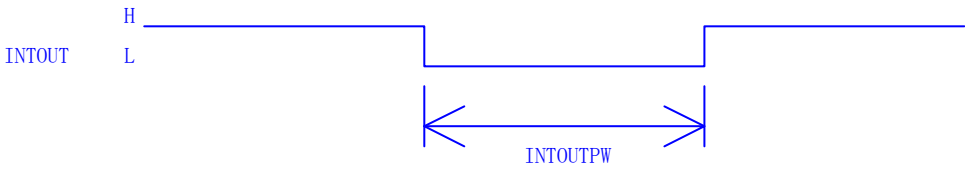
(Caution)

When writing to the frame buffer directly after executing this command, write cannot be performed normally. Wait for at least 32mS or longer, or confirm that bit 0 changes from 1 to 0 before shifting to the next write operation. (Bit 0 is the BUSY bit which outputs 1 directly after a hard clear command is issued, and goes back to 0 when completed.)

The LCD controller features an INTOUT pin (No. 141 pin). After the completion of hard fill, the active LOW signal is output from this pin, as shown in the following diagram.
In addition, the LOW width of the signal (INTOUTPW) is about 1 horizontal period.

- KS-LDTQ-2PI (QVGA-TFT): INTOUTPW = about 66.5 µsec

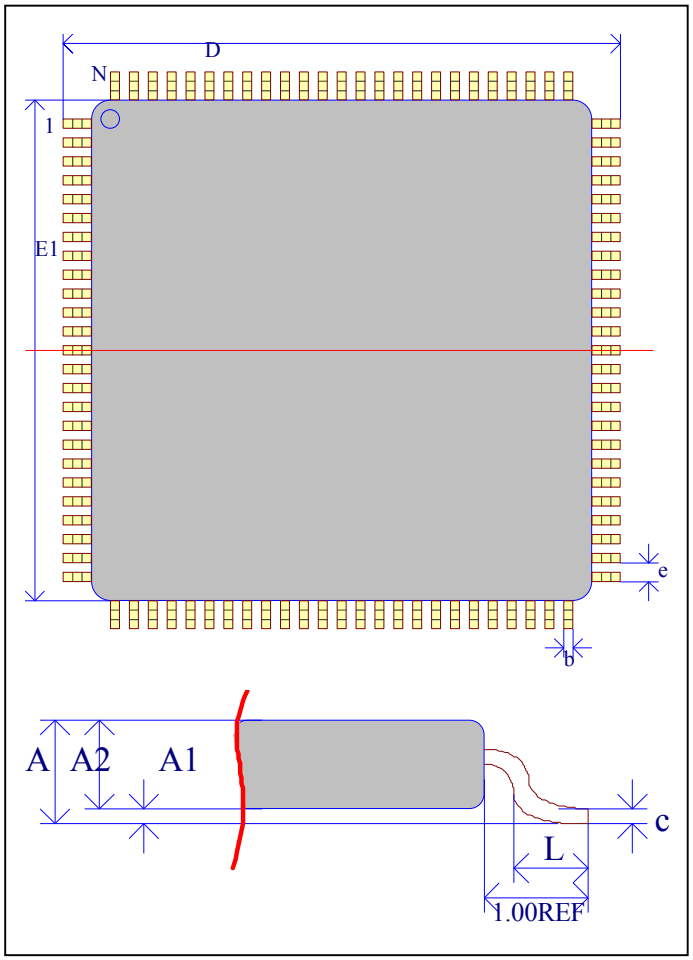
By connecting this signal to the IRQ (interrupt) port of the CPU, the completion of hard fill can be detected by interruption.



8. External Dimensions

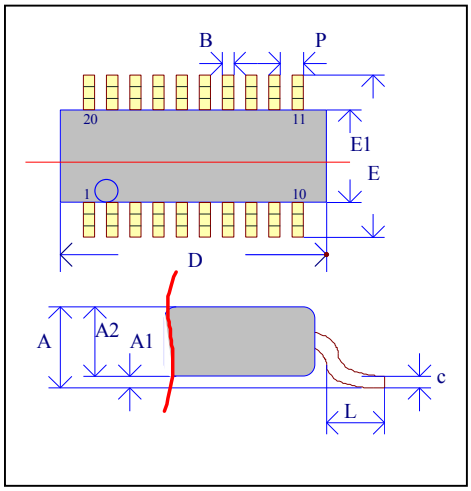
● KS-LDTQ-2PI

Sign	MIN(mm)	NOM(mm)	MAX(mm)
A			1.60
A1	0.05		0.15
A2	1.35	1.40	1.45
D		22.00 BSC	
E1		20.00 BSC	
E		0.50 BSC	
B	0.17	0.22	0.27
C	0.09	0.15	0.20
L	0.45	0.60	0.75
N		144	



● KS-R8TPC

Sign	MIN(mm)	NOM(mm)	MAX(mm)
A			1.45
A1	0	0.1	0.2
A2		1.15	
B	0.17	0.22	0.32
c	0.13	0.15	0.2
D	6.4	6.5	6.6
E1	4.3	4.4	4.5
p	0.53	0.65	0.77
E	6.2	6.4	6.6
L	0.3	0.5	0.7



9. Design Precautions

1) When Powering on

The LCD controller is a type that forwards configuration data from the flash memory inside the device to the SRAM.

After powering on, it starts quickly after disengaging the reset. However, the hard fill starts soon after powering on. When designing software, ensure that it checks the completion of the hard fill in the hard fill register before allowing read-write access.

10. Handling Precautions

1) Transport

Handle the Product and the packaging carefully. Do not throw or drop, as this can cause damage to the Product. When transporting, avoid mechanical vibration and shock as much as possible.

Moreover, avoid the Product getting wet during times of rain and snow, as it has a negative influence on the effectiveness of the antistatic materials (magazine, etc.) and the main Product itself.

2) Storage

① Avoid storing in areas at risk of water leakage and direct sunlight (be particularly careful during times of rain and snow.)

② Do not stack packaging boxes upside down or sideways.

③ The recommended ambient conditions for storage are a constant temperature and humidity in the ranges of 5~35℃ and 40~75%, respectively.

④ Avoid storing in areas prone to noxious fumes (in particular, corrosive gases) and high levels of dust.

⑤ Sudden temperature changes during storage result in condensation, causing the oxidation of leads and corrosion, and thus the deterioration of solder wettability. Store in areas not subject to frequent changes in temperature.

⑥ After taking the Product out of the package, use an antistatic container when storing again.

⑦ When storing, do not directly apply any loads on the Product.

⑧ After an extended period of normal storage (2 years or more), it is recommended to check the solderability and electrical characteristics before use.

3) Inspection

(1) Grounding

① Properly ground the floor, worktable, conveyor, floor mat, etc. so as to avoid a buildup of static electricity. In particular, always ground the worktable which has direct contact with the device and the antistatic floor mat (100k~100MΩ/cm^2).

② Always ground the electronic measuring instruments, the jig, and the soldering iron.

③ Workers should wear antistatic work wear, and the worker's body should be

grounded using an antistatic wrist strap. The antistatic wrist strap should be grounded at a resistance of about 0.5~1.0MΩ.

(2) Electrical Leakage

Leakage from the electrical inspection equipment and/or the Product-embedded system itself should be avoided to prevent damage to the semiconductors in the device, but above all for the worker's safety. Prior to using the circuit tester, curve tracer, synchroscope, other measuring instruments or other equipment such as the soldering iron that directly comes into contact with the Product, ensure that there is no leakage before grounding.

(3) Order of Inspection

① Before inspecting the Product, check for proper grounding and any leakage as described above. Additionally, apply voltage to the Product only after inserting into a jig. When doing so, avoid sudden startups and shut downs of the power supply.

② After completing inspection of the Product, switch off the applied voltage before removing it from the jig. If removed while powered on, deterioration and/or damage to the Product may occur.

(4) Electric Shock

During electrical measurement, there is possibility of electric shock from the lead or wiring, the connectors, the envelope, and/or the heat sink. Avoid bodily contact while powered on.

4) ESD (Deterioration/Damage from Electrostatic Discharge)

When handling the Product by itself, ensure that the environment is as static-free as possible, workers wear antistatic clothes, containers that have direct contact with the Product use antistatic material, and that proper grounding is used, with a resistance of 0.5~1.0MΩ.

(1) Management of the Work Environment

① When humidity decreases, static electricity can build up through friction. The recommended humidity level is 40~60%, after considering moisture absorption caused by the opening of moisture proof product packaging.

② Ground all equipment and jigs installed within the workspace.

③ Place and ground conductive mats on the workspace floor to prevent static electricity buildup on the floor (surface resistance 10^4~10^8Ω/sq., resistance between surface and grounding 7.5×10^5~10^8Ω/sq.).

④ Place and ground conductive mats (with resistance capability) on the worktable surface to diffuse static electricity (surface resistance:

10^4~10^8Ω/sq. resistance between surface and grounding: 7.5×10^5~10^8Ω/sq.). Avoid using a metal surface for the worktable that can create a sudden electrostatic discharge with low resistance when the Product comes into direct contact with it.

⑤ When using automated equipment, be careful of the following points.

(a) When picking up the IC package surface by vacuum, use conductive rubber at the pickup's tip to prevent electrostatic buildup.

(b) Minimize friction to the IC package surface. When friction can't be avoided due to the system, decrease the friction surface, or use materials with a smaller friction coefficient or electrical resistance, or consider using an ionizer.

(c) Use electrostatic dissipation materials for parts that come into contact with the lead pin of the Product.

(d) Avoid the Product coming into contact with electrostatically-charged objects (human body, work clothes, etc.).

(e) Utilize a tape carrier that uses a low-resistance material in the part where the tape comes into contact.

(f) Avoid contact between the jig equipment and the Product during the manufacturing process.

(g) For manufacturing processes that cause the package to become electrostatically charged, use an ionizer to neutralize the charge.

⑥ In the workspace, use a VDT filter to prevent electrostatic buildup on the CRT surface, and avoid switching on and off as much as possible during work. This is to prevent electromagnetic induction to the device.

⑦ Regularly measure the electrostatic potential of the workspace, to ensure that there is no buildup.

⑧ Use antistatic fiber covers on chairs, and ground the chairs to the floor with a grounding chain. (Resistance between chair surface and grounding chain: 7.5×10^5~10^{12}Ω/sq.)

⑨ Place antistatic mats on storage shelf surfaces.
(Surface resistance: 10^4~10^8Ω/sq., resistance between surface and grounding: 7.5×10^5~10^8Ω/sq.)

⑩ For shipping and temporary storage containers for the device (box, jig, bag, etc.), use a container made of electrostatic dissipation or antistatic material.

⑪ As for carts, use electrostatically conductive materials for surfaces that come into contact with the Product packaging, and ground to the floor by using a

grounding chain. (Resistance between cart surface and grounding chain: 7.5×10^{5}~$10^{10}\Omega$/sq.)

⑫ For electrostatically-controlled areas, place a grounding conductor exclusively for static electricity. For this grounding conductor, use a power transmission grounding conductor (class three and above or equivalent) or underground grounding conductor. In addition, it is recommended to separate it from the equipment grounding when feasible.

(2) Work Precautions

① Workers should wear anti-static clothes and conductive shoes (or heel strap, leg strap).

② Workers should also wear a wrist strap, grounded with a resistance of about 1.0MΩ.

③ Ground the tip of the soldering iron, and use with a low voltage (6V~24V).

④ Tweezers have a potential of contacting the Product's pins; as such, use an antistatic type and avoid metal tweezers as much as possible. With low resistance, metal tweezers can cause a sudden discharge from a charged Product. When utilizing vacuum tweezers, use a conductivity adsorption pad on the tip and ground using a grounding conductor exclusively for static electricity. (Resistance: 10^{4}~$10^{10}\Omega$)

⑤ Do not place the Product and its container near areas with a high electric field (eg. on the CRT, etc.).

⑥ When stacking PCBs with mounted semiconductors, place antistatic boards in between to avoid direct contact. Otherwise, static buildup and discharge may occur.

⑦ When bringing in items into an electrostatically-controlled area (clipboard, etc.), use items made of antistatic material as much as possible.

⑧ When touching the Product directly, wear antistatic gloves or finger cots/stalls. (Resistance: $10^{8}\Omega$ and under)

⑨ When placing safety covers for equipment near the device, use covers with a resistance of $10^{9}\Omega$ and under.

⑩ When use of a wrist strap is impossible, and friction to the device is likely, use an ionizer.

5) Disposal Precaution

When disposing of the device and the packaging. Please consider the environment and follow all local laws and regulations.

11. Operating Condition Precautions

1) Ambient Temperature

As a rule, semiconductors are more sensitive to the temperature than other components. As the various electrical characteristics are limited by operating temperature, determine the temperature environment in advance, and consider derating when designing the device. Furthermore, use of the Product beyond specifications not only means that the electrical characteristics cannot be guaranteed, but can also cause deterioration of the device.

2) Ambient Humidity

Molded devices are not perfectly airtight. Therefore, long-term use in highly humid environments can cause deterioration and damage to the semiconductor chips due to moisture penetration.

Moreover, for normal PCBs, highly humid environments can lead to lowered impedance between wirings. Therefore, for systems with high signal source impedance, these substrate leaks and leaks between pins in the Product can cause malfunctions. In such cases, consider humidity-proofing the Product surface. On the other hand, in low humidity, damage due to electrostatic discharge can become a problem, so use within a humidity range of 40~60% when not particularly humidity-proofing.

3) Corrosive Gas

Beware that corrosive gas can affect the device and cause deterioration of electrical characteristics.

An example of this is rubber near the device releases sulfuric gas (or condensation in high humidity), resulting in corrosion to leads, crystallization due to chemical reaction between leads and ensuing leakage.

4) Radiation/Cosmic rays

Generally, devices are not designed to resist radiation and cosmic rays. Therefore, for space applications and in environments with radiation, it is necessary to design specific protection for these factors.

5) Intense Electric Field/Magnetic Field

When the Product is exposed to magnetic fields, abnormal phenomenon (impedance variation and increase of current leaks, etc.) can occur due to polarization of the plastic material and the IC chip internals.

There was also a reported case of malfunction due to the installation of the LSI near the deflection yoke of a television set. In such cases, changing the

installation location and/or deploying an electromagnetic shield maybe necessary. In particular, in an alternating magnetic field, a shield is necessary due to the occurrence of electromotive forces.

6) Vibration/Impact/Stress

Cannon type devices with a hollow interior and those with a ceramic seal are vulnerable to vibration and shock because internal wire connections are not fixed. However, in actual devices, there have been reports that vibration, shock, or stress to soldered parts and connections leading to the snapping of wires. Therefore, care is necessary in designing equipment with a high vibration rate. It is also known that when stress is applied to the semiconductor chip through the package, a change in internal chip resistance can be caused by the Piezo effect. For analog circuits, be careful of stress to the package, as well. In particular, strong vibration, shock, or stress, can cause cracks in the package or chip.

7) Ambient Light (ultraviolet rays, sunlight, fluorescent lights, lamps, etc.)

When semiconductor devices are exposed to light, malfunctions can occur due to striking voltage caused by a photoelectric effect. In particular, devices with a view of the internal chip are affected by this, so the design should not allow ambient light to enter. Care must be taken as devices other than photo semiconductors and EP-ROMs can be affected by this.

8) Dust/Oil

Similar to corrosive gas, chemical reactions may occur in the device due to dust or oil. As such, avoid environments where dust and oil can enter the device, since they can affect the device characteristics. Care must be taken in designing optical devices, since, in addition to the above, optical characteristics can be affected.

9) Smoke/Fire

Semiconductor devices and modular devices are not fire-resistant, and as such, combustion is possible. In such cases, the device may emit toxic gases.

Therefore, avoid areas with open flames, heated elements, and combustible/flammable objects.

12. Installation Method

The following are the reflow conditions for the LCD controller and touch panel controller. For more details, please make an inquiry to our sales staff.

1) LCD Controller KS-LDTQ-2PI

The peak temperature and the peak temperature times for reflow are subject to the following conditions.

- Peak Temperature ・・・ 260℃ (+0/-5℃)
- Peak Temperature Time within 5 ℃ (255℃~260℃) ・・・ 20~40 seconds

2) Touch Panel Controller KS-R8TPC

The peak temperature and the peak temperature times for reflow are subject to the following conditions.

- Peak Temperature ・・・ 260℃ Max.
- Peak Temperature Time within 5 ℃ (255℃~260℃) ・・・ 16 seconds max.