INTEGRATED CIRCUITS

DATA SHEET

For a complete data sheet, please also download:

- The IC06 74HC/HCT/HCU/HCMOS Logic Family Specifications
- The IC06 74HC/HCT/HCU/HCMOS Logic Package Information
- The IC06 74HC/HCT/HCU/HCMOS Logic Package Outlines

74HC/HCT595
8-bit serial-in/serial or parallel-out shift register with output latches; 3-state

Product specification
Supersedes data of September 1993
File under Integrated Circuits, IC06

1998 Jun 04

Philips Semiconductors

PHILIPS

8-bit serial-in/serial or parallel-out shift register with output latches; 3-state

74HC/HCT595

FEATURES

- 8-bit serial input
- 8-bit serial or parallel output
- Storage register with 3-state outputs
- Shift register with direct clear
- 100 MHz (typ) shift out frequency
- Output capability:
  - parallel outputs; bus driver
  - serial output; standard
- I_{CC} category: MSI.

APPLICATIONS

- Serial-to-parallel data conversion
- Remote control holding register.

DESCRIPTION

The 74HC/HCT595 are high-speed Si-gate CMOS devices and are pin compatible with low power Schottky TTL (LSTTL). They are specified in compliance with JEDEC standard no. 7A.

The “595” is an 8-stage serial shift register with a storage register and 3-state outputs. The shift register and storage register have separate clocks.

Data is shifted on the positive-going transitions of the SH_{CP} input. The data in each register is transferred to the storage register on a positive-going transition of the ST_{CP} input. If both clocks are connected together, the shift register will always be one clock pulse ahead of the storage register.

The shift register has a serial input (D_S) and a serial standard output (Q_7’) for cascading. It is also provided with asynchronous reset (active LOW) for all 8 shift register stages. The storage register has 8 parallel 3-state bus driver outputs. Data in the storage register appears at the output whenever the output enable input (OE) is LOW.

QUICK REFERENCE DATA

GND = 0 V; T_{amb} = 25 °C; $t_r = t_f$ = 6 ns.

SYMBOL	PARAMETER	CONDITIONS	TYP.		UNIT
			HC	HCT	
t_{PHL}/t_{PLH}	propagation delay	C_L = 15 pF; V_{CC} = 5 V			
	SH_{CP} to Q_7’		16	21	ns
	ST_{CP} to Q_n		17	20	ns
	$\overline{MR}$ to Q_7’		14	19	ns
f_{max}	maximum clock frequency SH_{CP}, ST_{CP}		100	57	MHz
C_I	input capacitance		3.5	3.5	pF
C_{PD}	power dissipation capacitance per package	notes 1 and 2	115	130	pF

Notes

1. C_{PD} is used to determine the dynamic power dissipation (P_D in μW):

   $P_D = C_{PD} \times V_{CC}^2 \times f_i + \sum (C_L \times V_{CC}^2 \times f_o)$ where:

   f_i = input frequency in MHz

   f_o = output frequency in MHz

   $\sum(C_L \times V_{CC}^2 \times f_o)$ = sum of outputs

   C_L = output load capacitance in pF

   V_{CC} = supply voltage in V
2. For HC the condition is V_I = GND to V_{CC}; for HCT the condition is V_I = GND to V_{CC} – 1.5 V.

ORDERING INFORMATION

TYPE NUMBER	PACKAGE		
	NAME	DESCRIPTION	VERSION
74HC595N	DIP16	plastic dual in-line package; 16 leads (300 mil); long body	SOT38-1
74HC595D	SO16	plastic small outline package; 16 leads; body width 3.9 mm	SOT109-1
74HC595DB	SSOP16	plastic shrink small outline package; 16 leads; body width 5.3 mm	SOT338-1
74HC595PW	TSSOP16	plastic thin shrink small outline package; 16 leads; body width 4.4 mm	SOT403-1
74HCT595N	DIP16	plastic dual in-line package; 16 leads (300 mil); long body	SOT38-1
74HCT595D	SO16	plastic small outline package; 16 leads; body width 3.9 mm	SOT109-1

PINNING

SYMBOL	PIN	DESCRIPTION
Q_0 to Q_7	15, 1 to 7	parallel data output
GND	8	ground (0 V)
Q_7’	9	serial data output
$\overline{MR}$	10	master reset (active LOW)
SH_{CP}	11	shift register clock input
ST_{CP}	12	storage register clock input
$\overline{OE}$	13	output enable (active LOW)
D_S	14	serial data input
V_{CC}	16	positive supply voltage

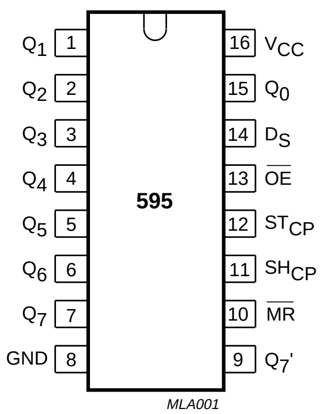


Fig.1 Pin configuration.

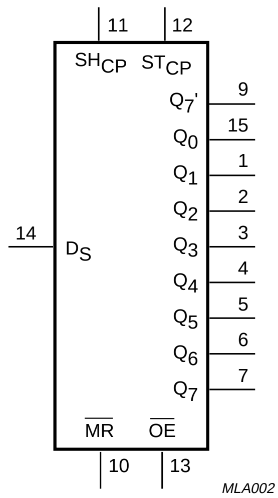


Fig.2 Logic symbol.

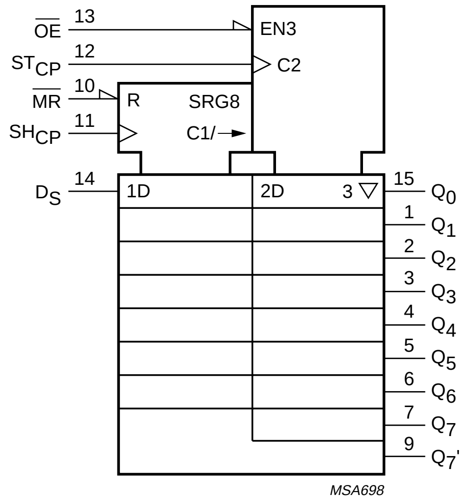


Fig.3 IEC logic symbol.

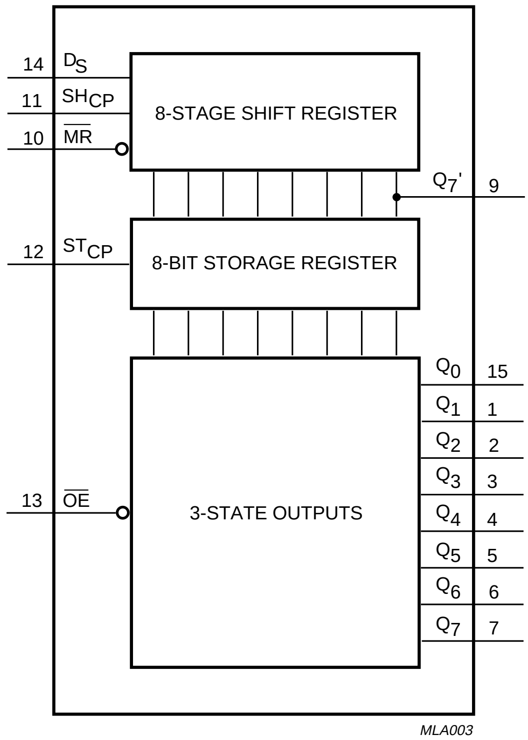


Fig.4 Functional diagram.

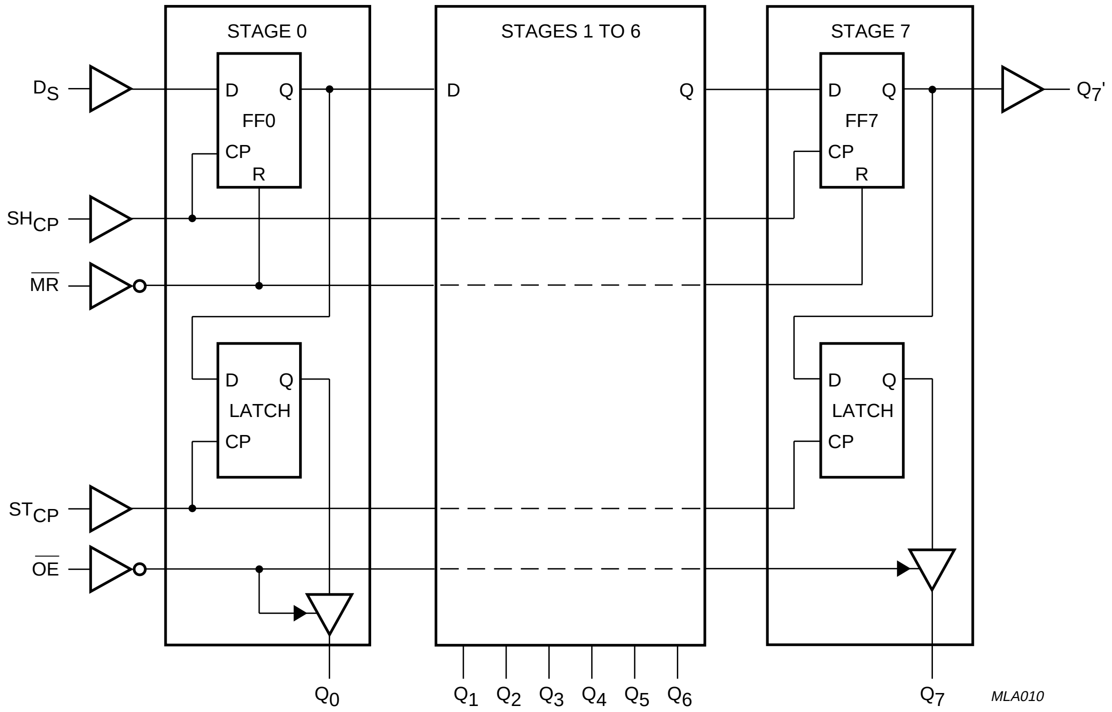


Fig.5 Logic diagram.

FUNCTION TABLE

INPUTS					OUTPUTS		FUNCTON
SH_{CP}	**ST_{CP}**	**$\overline{OE}$**	**$\overline{MR}$**	**D_S**	**Q_7’**	**Q_N**	
X	X	L	L	X	L	NC	a LOW level on $\overline{MR}$ only affects the shift registers
X	↑	L	L	X	L	L	empty shift register loaded into storage register
X	X	H	L	X	L	Z	shift register clear. Parallel outputs in high-impedance OFF-state
↑	X	L	H	H	Q_6’	NC	logic high level shifted into shift register stage 0. Contents of all shift register stages shifted through, e.g. previous state of stage 6 (internal Q_6’) appears on the serial output (Q_7’)
X	↑	L	H	X	NC	Q_n’	contents of shift register stages (internal Q_n’) are transferred to the storage register and parallel output stages
↑	↑	L	H	X	Q_6’	Q_n’	contents of shift register shifted through. Previous contents of the shift register is transferred to the storage register and the parallel output stages.

Notes

1. H = HIGH voltage level; L = LOW voltage level
   ↑ = LOW-to-HIGH transition; ↓ = HIGH-to-LOW transition
   Z = high-impedance OFF-state; NC = no change
   X = don’t care.

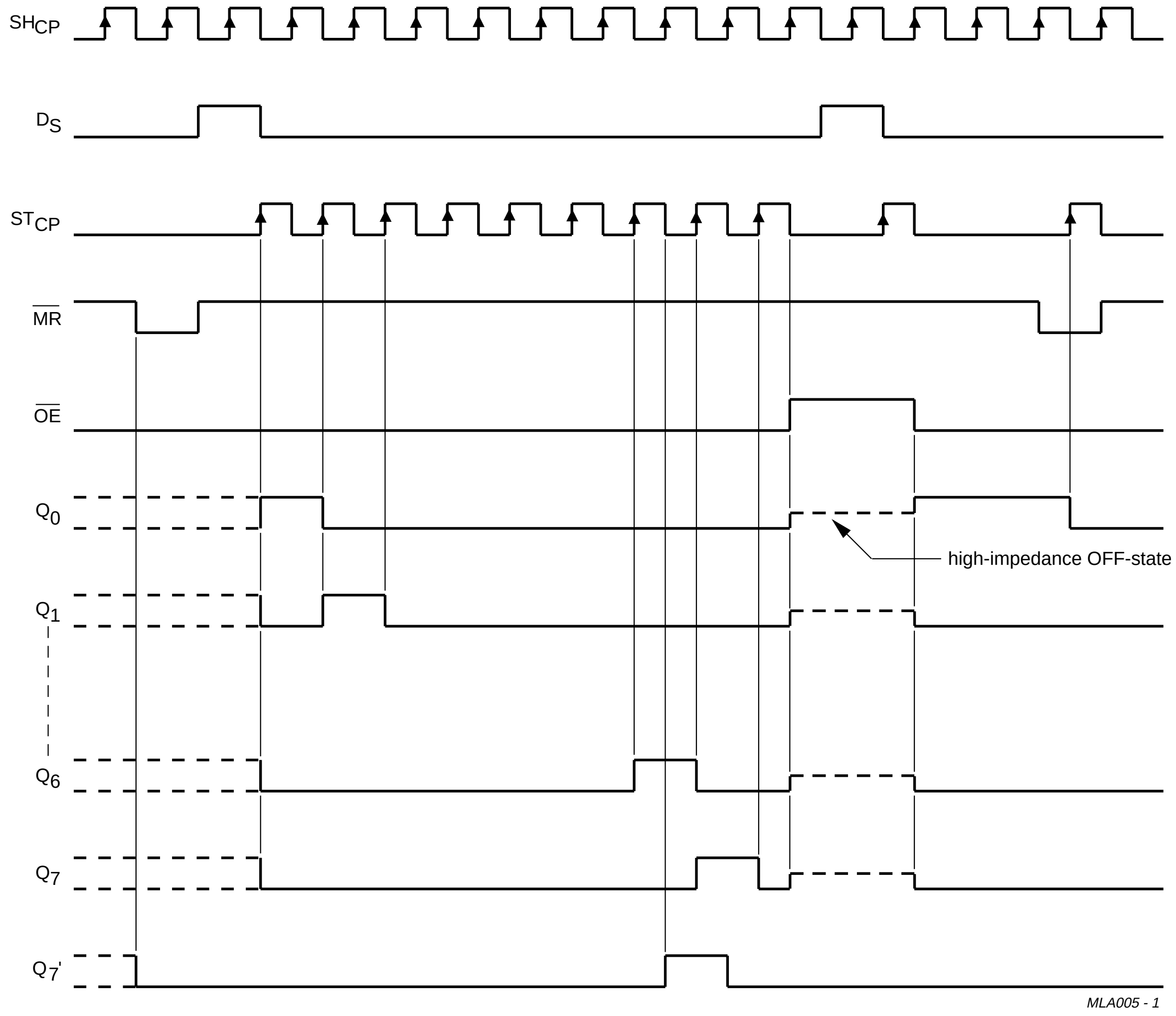


Fig.6 Timing diagram.

DC CHARACTERISTICS FOR 74HC

For the DC characteristics see chapter *"74HC/HCT/HCU/HCMOS Logic Family Specifications"*.

Output capability: parallel outputs, bus driver, serial output, standard I_{CC} category: MSI.

AC CHARACTERISTICS FOR 74HC

GND = 0 V; $t_r = t_f$ = 6 ns; C_L = 50 pF.

SYMBOL	PARAMETER	T_{amb} (°C)							UNIT	TEST CONDITION	
		+25			−40 to +85		−40 to +125			V_{CC} (V)	WAVEFORMS
		min	typ	max	min	max	min	max			
t_{PHL}/t_{PLH}	propagation delay SH_{CP} to Q_7'	– – –	52 19 15	160 32 27	– – –	200 40 34	– – –	240 48 41	ns	2.0 4.5 6.0	Fig.7
t_{PHL}/t_{PLH}	propagation delay ST_{CP} to Q_n	– – –	55 20 16	175 35 30	– – –	220 44 37	– – –	265 53 45	ns	2.0 4.5 6.0	Fig.8
t_{PHL}	propagation delay $\overline{MR}$ to Q_7'	– – –	47 17 14	175 35 30	– – –	220 44 37	– – –	265 53 45	ns	2.0 4.5 6.0	Fig.10
t_{PZH}/t_{PZL}	3-state output enable time $\overline{OE}$ to Q_n	– – –	47 17 14	150 30 26	– – –	190 38 33	– – –	225 45 38	ns	2.0 4.5 6.0	Fig.11
t_{PHZ}/t_{PLZ}	3-state output disable time $\overline{OE}$ to Q_n	– – –	41 15 12	150 30 26	– – –	190 38 33	– – –	225 45 38	ns	2.0 4.5 6.0	Fig.11
t_W	shift clock pulse width HIGH or LOW	75 15 13	17 6 5	– – –	95 19 16	– – –	110 22 19	– – –	ns	2.0 4.5 6.0	Fig.7
t_W	storage clock pulse width HIGH or LOW	75 15 13	11 4 3	– – –	95 19 16	– – –	110 22 19	– – –	ns	2.0 4.5 6.0	Fig.8
t_W	master reset pulse width LOW	75 15 13	17 6.0 5.0	– – –	95 19 16	– – –	110 22 19	– – –	ns	2.0 4.5 6.0	Fig.10
t_{su}	set-up time D_S to SH_{CP}	50 10 9.0	11 4.0 3.0	– – –	65 13 11	– – –	75 15 13	– – –	ns	2.0 4.5 6.0	Fig.9
t_{su}	set-up time SH_{CP} to ST_{CP}	75 15 13	22 8 7	– – –	95 19 16	– – –	110 22 19	– – –	ns	2.0 4.5 6.0	Fig.8

SYMBOL	PARAMETER	T_{amb} (°C)							UNIT	TEST CONDITION	
		+25			−40 to +85		−40 to +125			V_{CC} (V)	WAVEFORMS
		min	typ	max	min	max	min	max			
t_h	hold time D_S to SH_{CP}	3	–6	–	3	–	3	–	ns	2.0	Fig.9
		3	–2	–	3	–	3	–		4.5	
		3	–2	–	3	–	3	–		6.0	
t_{rem}	removal time $\overline{MR}$ to SH_{CP}	50	–19	–	65	–	75	–	ns	2.0	Fig.10
		10	–7	–	13	–	15	–		4.5	
		9	–6	–	11	–	13	–		6.0	
f_{max}	maximum clock pulse frequency SH_{CP} or ST_{CP}	9	30	–	4.8	–	4	–	MHz	2.0	Figs 7 and 8
		30	91	–	24	–	20	–		4.5	
		35	108	–	28	–	24	–		6.0	

DC CHARACTERISTICS FOR 74HCT

For the DC characteristics see chapter *"74HC/HCT/HCU/HCMOS Logic Family Specifications"*.

Output capability: parallel outputs, bus driver; serial output, standard I_{CC} category: MSI.

Note to HCT types

The value of additional quiescent supply current (ΔI_{CC}) for a unit load of 1 is given in the family specifications.
To determine ΔI_{CC} per input, multiply this value by the unit load coefficient shown in the table below.

GND = 0 V; $t_r = t_f$ = 6 ns; C_L = 50 pF.

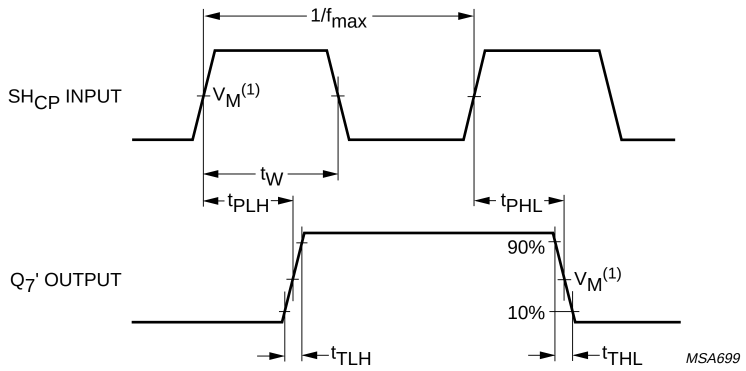
INPUT	UNIT LOAD COEFFICIENT
D_S	0.25
$\overline{MR}$	1.50
SH_{CP}	1.50
ST_{CP}	1.50
$\overline{OE}$	1.50

AC CHARACTERISTICS FOR 74HCT

GND = 0 V; $t_r = t_f = 6$ ns; $C_L = 50$ pF.

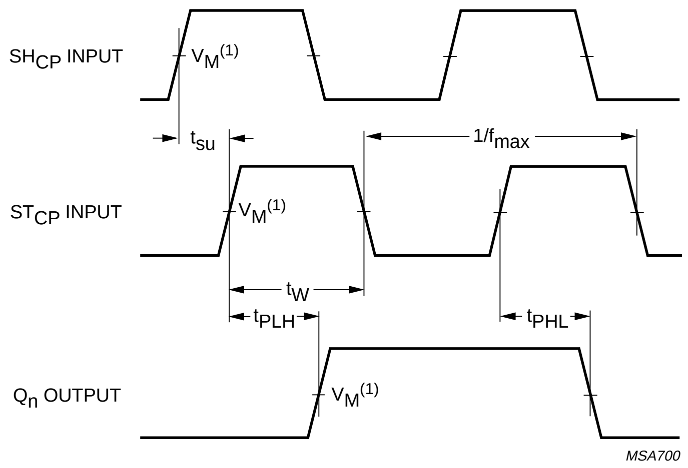
SYMBOL	PARAMETER	T_{amb} (°C)							UNIT	TEST CONDITION	
		+25			−40 to +85		−40 to +125			V_{CC} (V)	WAVEFORMS
		min	typ	max	min	max	min	max			
t_{PHL}/ t_{PLH}	propagation delay SH_{CP} to Q_7’	–	25	42	–	53	–	63	ns	4.5	Fig.7
t_{PHL}/ t_{PLH}	propagation delay ST_{CP} to Q_n	–	24	40	–	50	–	60	ns	4.5	Fig.8
t_{PHL}	propagation delay $\overline{MR}$ to Q_7’	–	23	40	–	50	–	60	ns	4.5	Fig.10
t_{PZH}/ t_{PZL}	3-state output enable time $\overline{OE}$ to Q_n	–	21	35	–	44	–	53	ns	4.5	Fig.11
t_{PHZ}/ t_{PLZ}	3-state output disable time $\overline{OE}$ to Q_n	–	18	30	–	38	–	45	ns	4.5	Fig.11
t_W	shift clock pulse width HIGH or LOW	16	6	–	20	–	24	–	ns	4.5	Fig.7
t_W	storage clock pulse width HIGH or LOW	16	5	–	20	–	24	–	ns	4.5	Fig.8
t_W	master reset pulse width LOW	20	8	–	25	–	30	–	ns	4.5	Fig.10
t_{su}	set-up time D_S to SH_{SP}	16	5	–	20	–	24	–	ns	4.5	Fig.9
t_{su}	set-up time SH_{CP} to ST_{CP}	16	8	–	20	–	24	–	ns	4.5	Fig.8
t_h	hold time D_S to SH_{CP}	3	−2	–	3	–	3	–	ns	4.5	Fig.9
t_{rem}	removal time $\overline{MR}$ to SH_{CP}	10	−7	–	13	–	15	–	ns	4.5	Fig.10
f_{max}	maximum clock pulse frequency SH_{CP} or ST_{CP}	30	52	–	24	–	20	–	MHz	4.5	Figs 7 and 8

AC WAVEFORMS



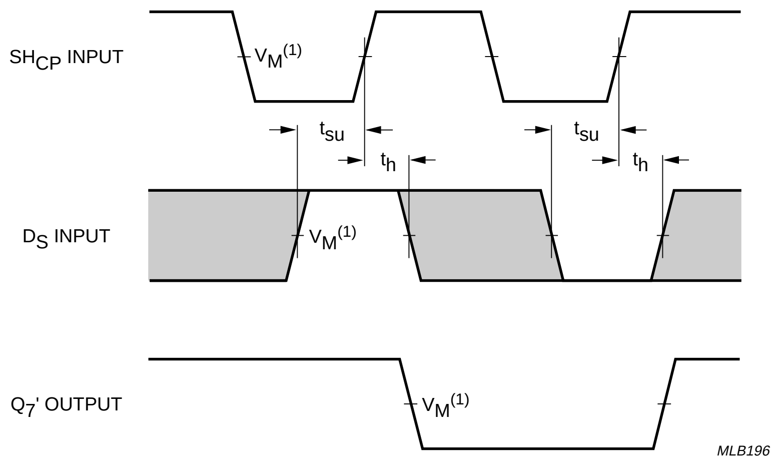
(1) HC: V_M = 50%; V_I = GND to V_{CC}
HCT: V_M = 1.3 V; V_I = GND to 3 V.

Fig.7 Waveforms showing the clock (SH_{CP}) to output (Q_7') propagation delays, the shift clock pulse width and maximum shift clock frequency.



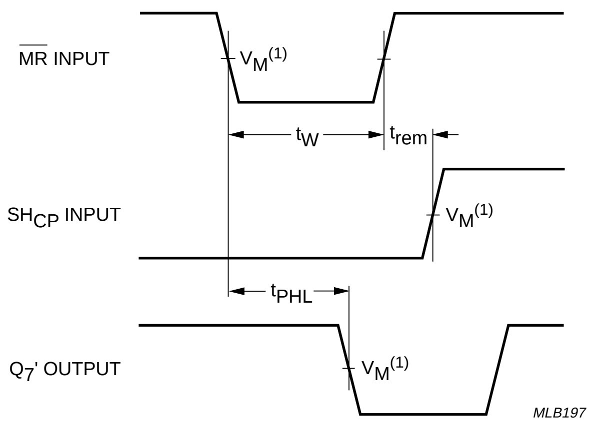
(1) HC: V_M = 50%; V_I = GND to V_{CC}
HCT: V_M = 1.3 V; V_I = GND to 3 V.

Fig.8 Waveforms showing the storage clock (ST_{CP}) to output (Q_n) propagation delays, the storage clock pulse width and the shift clock to storage clock set-up time.



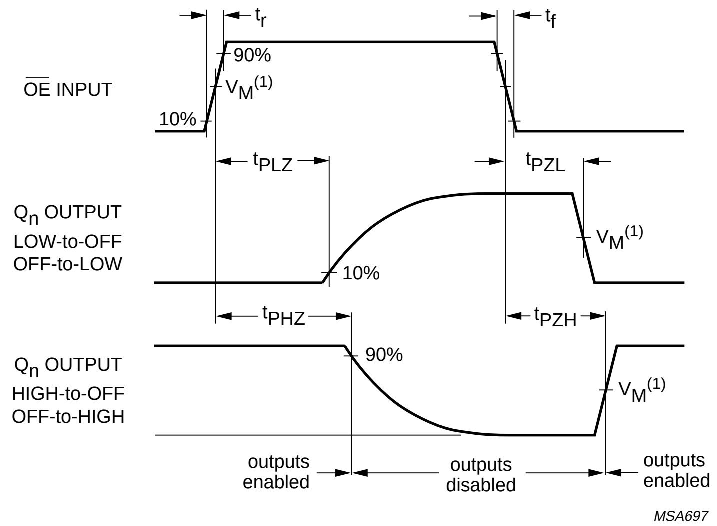
(1) HC: V_M = 50%; V_I = GND to V_{CC}
HCT: V_M = 1.3 V; V_I = GND to 3 V.

Fig.9 Waveforms showing the data set-up and hold times for the D_S input.



(1) HC: V_M = 50%; V_I = GND to V_{CC}
HCT: V_M = 1.3 V; V_I = GND to 3 V.

Fig.10 Waveforms showing the master reset ($\overline{MR}$) pulse width, the master reset to output (Q_7') propagation delay and the master reset to shift clock (SH_{CP}) removal time.

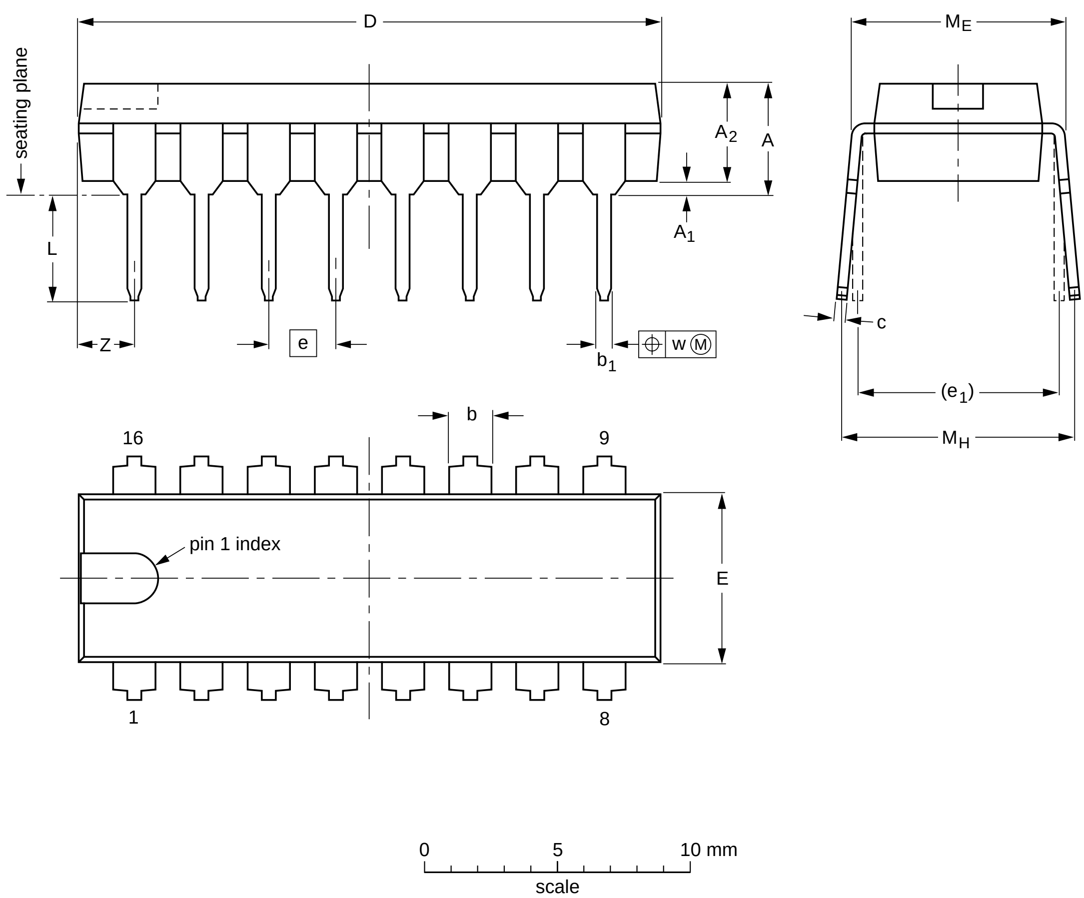


(1) HC: V_M = 50%; V_I = GND to V_{CC}
HCT: V_M = 1.3 V; V_I = GND to 3 V.

Fig.11 Waveforms showing the 3-state enable and disable times for input $\overline{OE}$.

PACKAGE OUTLINES

DIP16: plastic dual in-line package; 16 leads (300 mil); long body **SOT38-1**



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

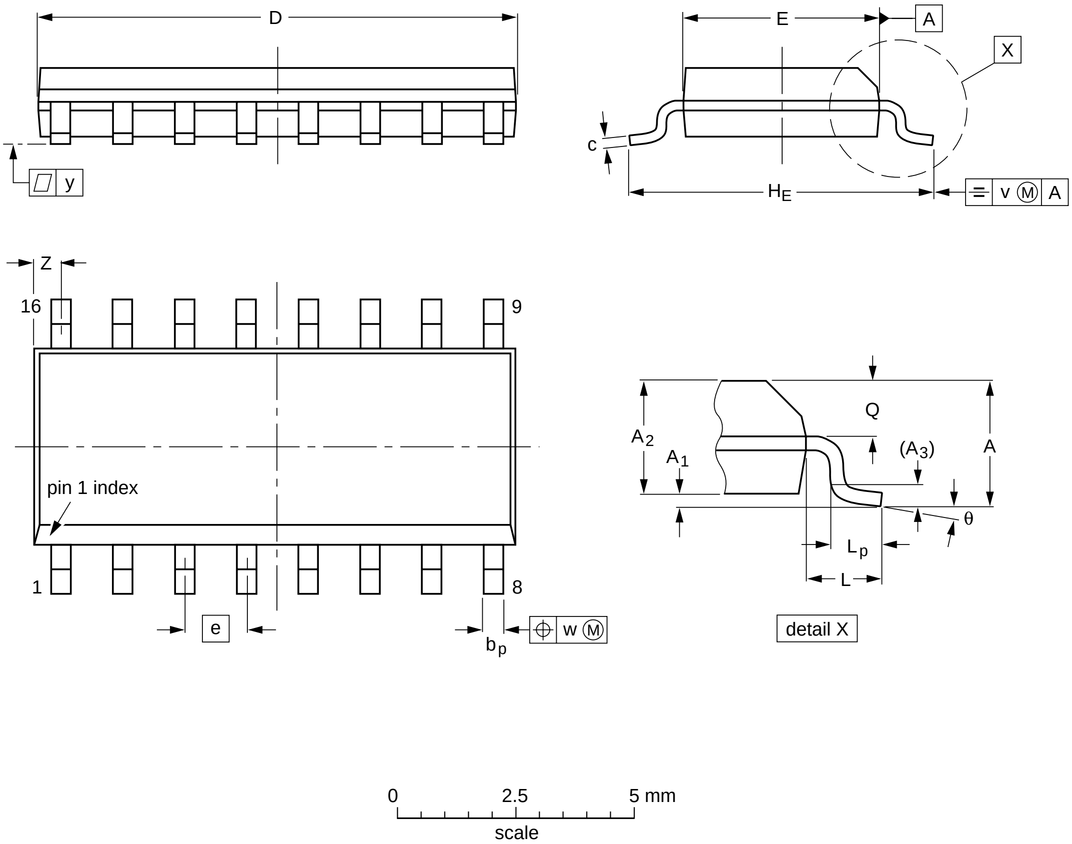
UNIT	A max.	A_1 min.	A_2 max.	b	b_1	c	D (1)	E (1)	e	e_1	L	M_E	M_H	w	Z (1) max.
mm	4.7	0.51	3.7	1.40 1.14	0.53 0.38	0.32 0.23	21.8 21.4	6.48 6.20	2.54	7.62	3.9 3.4	8.25 7.80	9.5 8.3	0.254	2.2
inches	0.19	0.020	0.15	0.055 0.045	0.021 0.015	0.013 0.009	0.86 0.84	0.26 0.24	0.10	0.30	0.15 0.13	0.32 0.31	0.37 0.33	0.01	0.087

Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT38-1	050G09	MO-001AE				~~92-10-02~~ 95-01-19

SO16: plastic small outline package; 16 leads; body width 3.9 mm **SOT109-1**



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

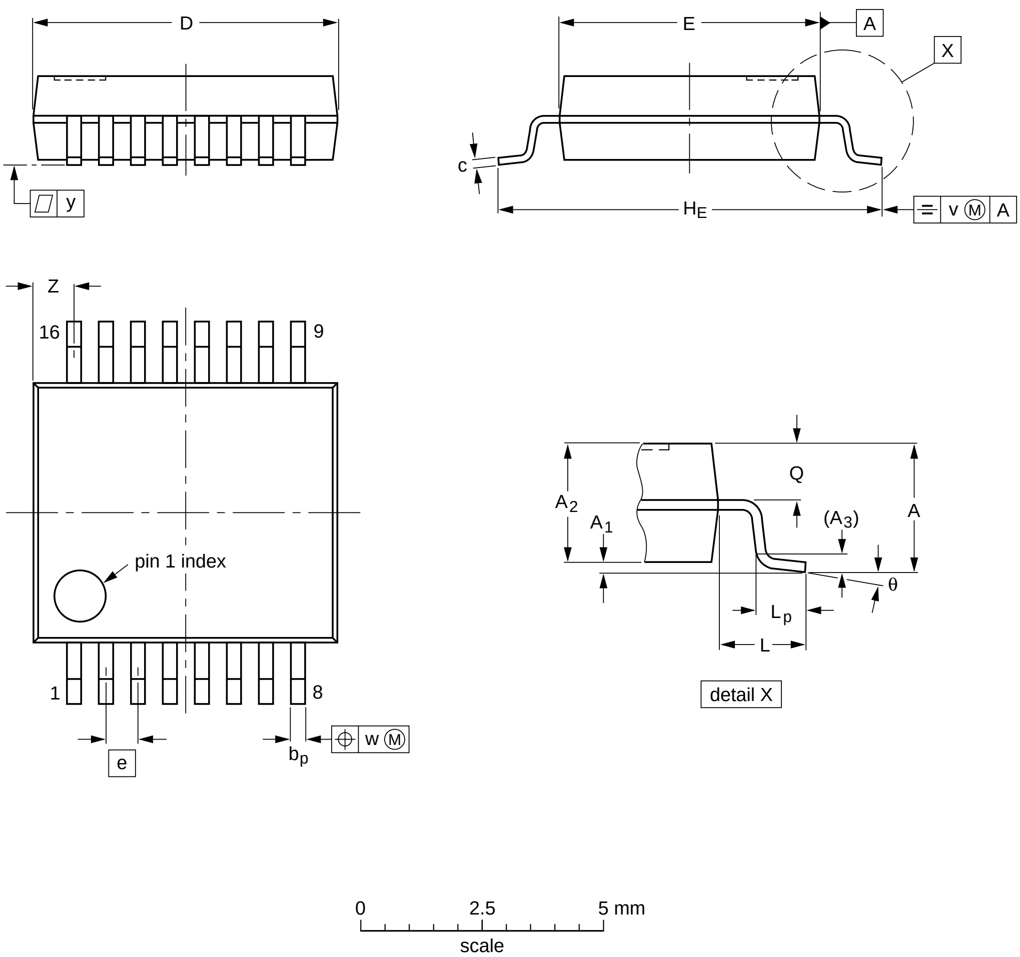
UNIT	A max.	A_1	A_2	A_3	b_p	c	D (1)	E (1)	e	H_E	L	L_p	Q	v	w	y	Z (1)	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	10.0 9.8	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8^o 0^o
inches	0.069	0.010 0.004	0.057 0.049	0.01	0.019 0.014	0.0100 0.0075	0.39 0.38	0.16 0.15	0.050	0.244 0.228	0.041	0.039 0.016	0.028 0.020	0.01	0.01	0.004	0.028 0.012	

Note

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT109-1	076E07S	MS-012AC				~~95-01-23~~ 97-05-22

SSOP16: plastic shrink small outline package; 16 leads; body width 5.3 mm **SOT338-1**

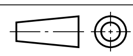


DIMENSIONS (mm are the original dimensions)

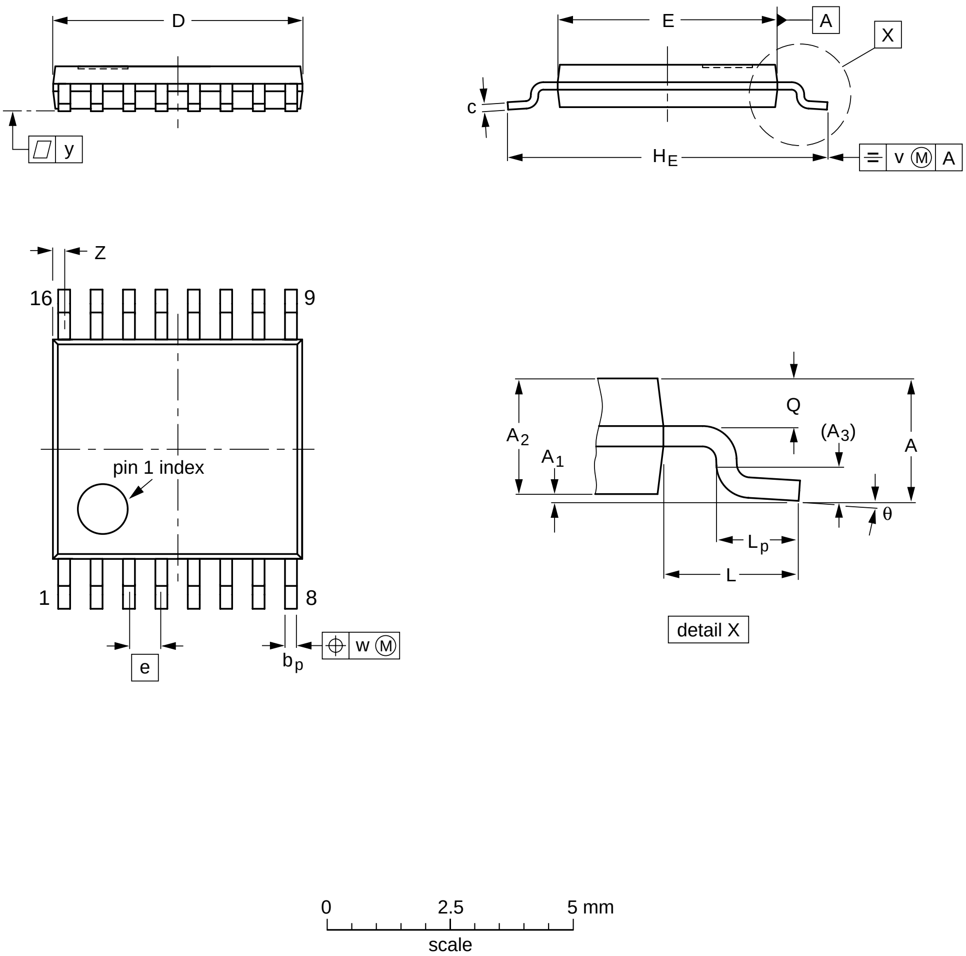
UNIT	A max.	A_1	A_2	A_3	b_p	c	D (1)	E (1)	e	H_E	L	L_p	Q	v	w	y	Z (1)	θ
mm	2.0	0.21 0.05	1.80 1.65	0.25	0.38 0.25	0.20 0.09	6.4 6.0	5.4 5.2	0.65	7.9 7.6	1.25	1.03 0.63	0.9 0.7	0.2	0.13	0.1	1.00 0.55	8^o 0^o

Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT338-1		MO-150AC				~~94-01-14~~ 95-02-04

TSSOP16: plastic thin shrink small outline package; 16 leads; body width 4.4 mm **SOT403-1**



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	D (1)	E (2)	e	H_E	L	L_p	Q	v	w	y	Z (1)	θ
mm	1.10	0.15 0.05	0.95 0.80	0.25	0.30 0.19	0.2 0.1	5.1 4.9	4.5 4.3	0.65	6.6 6.2	1.0	0.75 0.50	0.4 0.3	0.2	0.13	0.1	0.40 0.06	8° 0°

Notes

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic interlead protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT403-1		MO-153				~~94-07-12~~ 95-04-04

SOLDERING

Introduction

There is no soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and surface mounted components are mixed on one printed-circuit board. However, wave soldering is not always suitable for surface mounted ICs, or for printed-circuits with high population densities. In these situations reflow soldering is often used.

This text gives a very brief insight to a complex technology. A more in-depth account of soldering ICs can be found in our *"Data Handbook IC26; Integrated Circuit Packages"* (order code 9398 652 90011).

DIP

SOLDERING BY DIPPING OR BY WAVE

The maximum permissible temperature of the solder is 260 °C; solder at this temperature must not be in contact with the joint for more than 5 seconds. The total contact time of successive solder waves must not exceed 5 seconds.

The device may be mounted up to the seating plane, but the temperature of the plastic body must not exceed the specified maximum storage temperature ($T_{stg\ max}$). If the printed-circuit board has been pre-heated, forced cooling may be necessary immediately after soldering to keep the temperature within the permissible limit.

REPAIRING SOLDERED JOINTS

Apply a low voltage soldering iron (less than 24 V) to the lead(s) of the package, below the seating plane or not more than 2 mm above it. If the temperature of the soldering iron bit is less than 300 °C it may remain in contact for up to 10 seconds. If the bit temperature is between 300 and 400 °C, contact may be up to 5 seconds.

SO, SSOP and TSSOP

REFLOW SOLDERING

Reflow soldering techniques are suitable for all SO, SSOP and TSSOP packages.

Reflow soldering requires solder paste (a suspension of fine solder particles, flux and binding agent) to be applied to the printed-circuit board by screen printing, stencilling or pressure-syringe dispensing before package placement.

Several techniques exist for reflowing; for example, thermal conduction by heated belt. Dwell times vary between 50 and 300 seconds depending on heating method.

Typical reflow temperatures range from 215 to 250 °C. Preheating is necessary to dry the paste and evaporate the binding agent. Preheating duration: 45 minutes at 45 °C.

WAVE SOLDERING

Wave soldering can be used for all SO packages. Wave soldering is **not** recommended for SSOP and TSSOP packages, because of the likelihood of solder bridging due to closely-spaced leads and the possibility of incomplete solder penetration in multi-lead devices.

If wave soldering is used - **and cannot be avoided for SSOP and TSSOP packages** - the following conditions must be observed:

- A double-wave (a turbulent wave with high upward pressure followed by a smooth laminar wave) soldering technique should be used.
- The longitudinal axis of the package footprint must be parallel to the solder flow and must incorporate solder thieves at the downstream end.

Even with these conditions:

- **Only consider wave soldering SSOP packages that have a body width of 4.4 mm, that is SSOP16 (SOT369-1) or SSOP20 (SOT266-1).**
- **Do not consider wave soldering TSSOP packages with 48 leads or more, that is TSSOP48 (SOT362-1) and TSSOP56 (SOT364-1).**

During placement and before soldering, the package must be fixed with a droplet of adhesive. The adhesive can be applied by screen printing, pin transfer or syringe dispensing. The package can be soldered after the adhesive is cured.

Maximum permissible solder temperature is 260 °C, and maximum duration of package immersion in solder is 10 seconds, if cooled to less than 150 °C within 6 seconds. Typical dwell time is 4 seconds at 250 °C.

A mildly-activated flux will eliminate the need for removal of corrosive residues in most applications.

REPAIRING SOLDERED JOINTS

Fix the component by first soldering two diagonally-opposite end leads. Use only a low voltage soldering iron (less than 24 V) applied to the flat part of the lead. Contact time must be limited to 10 seconds at up to 300 °C. When using a dedicated tool, all other leads can be soldered in one operation within 2 to 5 seconds between 270 and 320 °C.

DEFINITIONS

Data sheet status	
Objective specification	This data sheet contains target or goal specifications for product development.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later.
Product specification	This data sheet contains final product specifications.
Limiting values	
Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.	
Application information	
Where application information is given, it is advisory and does not form part of the specification.	

LIFE SUPPORT APPLICATIONS

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Philips customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Philips for any damages resulting from such improper use or sale.

This datasheet has been download from:

www.datasheetcatalog.com

Datasheets for electronics components.

pH Sensor
(Order Code PH-BTA)

Our pH Sensor can be used for any lab or demonstration that can be done with a traditional pH meter, including: acid-base titrations, monitoring pH in an aquarium, and investigating the water quality of streams and lakes.

Inventory of Items Included with the pH Sensor

- pH Sensor
- Electrode Storage bottle, containing pH 4/KCl solution

NOTE: Vernier products are designed for educational use. Our products are not designed nor recommended for any industrial, medical, or commercial process such as life support, patient diagnosis, control of a manufacturing process, or industrial testing of any kind.

Collecting Data with the pH Sensor

This sensor can be used with the following interfaces to collect data.

- Vernier LabQuest® 2 or original LabQuest as a standalone device or with a computer
- Vernier LabQuest Mini with a computer
- Vernier LabPro® with a computer or TI graphing calculator
- Vernier Go!®Link
- Vernier EasyLink®
- Vernier SensorDAQ®
- CBL 2™
- TI-Nspire™ Lab Cradle

Here is the general procedure to follow when using the pH Sensor:
1. Connect the pH Sensor to the interface.
2. Start the data-collection software.
3. The software will identify the pH Sensor and load a default data-collection setup. You are now ready to collect data.

Important: Do not fully submerge the sensor. The handle is not waterproof.

Data-Collection Software

This sensor can be used with an interface and the following data-collection software.

- **Logger *Pro* 3** This computer program is used with LabQuest 2, LabQuest, LabQuest Mini, LabPro, or Go! Link.
- **Logger Lite** This computer program is used with LabQuest 2, LabQuest, LabQuest Mini, LabPro, or Go! Link.
- **LabQuest App** This program is used when LabQuest 2 or LabQuest is used as a standalone device.
- **DataQuest™ Software for TI-Nspire™** This calculator application for the TI-Nspire™ can be used with the EasyLink or TI-Nspire™ Lab Cradle.
- **EasyData App** This calculator application for the TI-83 Plus and TI-84 Plus can be used with CBL 2, LabPro, and Vernier EasyLink. We recommend version 2.0 or newer, which can be downloaded from the Vernier web site, www.vernier.com/easy/easydata.html, and then transferred to the calculator. See the Vernier web site, www.vernier.com/calc/software/index.html for more information on the App and Program Transfer Guidebook.
- **DataMate program** Use DataMate with LabPro or CBL 2 and TI-73, TI-83, TI-84, TI-86, TI-89, and Voyage 200 calculators. See the LabPro and CBL 2™ Guidebooks for instructions on transferring DataMate to the calculator.
- **LabVIEW™** National Instruments LabVIEW™ software is a graphical programming language sold by National Instruments. It is used with SensorDAQ and can be used with a number of other Vernier interfaces. See www.vernier.com/labview for more information.

This sensor is equipped with circuitry that supports auto-ID. When used with LabQuest 2, LabQuest, LabQuest Mini, LabPro, Go! Link, SensorDAQ, TI-Nspire™ Lab Cradle, EasyLink, or CBL 2™, the data-collection software identifies the sensor and uses pre-defined parameters to configure an experiment appropriate to the recognized sensor.

How the pH Sensor Works

The pH amplifier inside the handle is a circuit which allows the standard combination pH electrode to be monitored by a lab interface. The cable from the pH amplifier ends in a BTA plug.

The pH Sensor will produce a voltage of approximately 1.75 volts in a pH 7 buffer. The voltage will increase by about 0.25 volts for every pH number decrease. The voltage will decrease by about 0.25 volts/pH number as the pH increases.

The Vernier gel-filled pH Sensor is designed to make measurements in the pH range of 0 to 14. The gel-filled reference half cell is sealed; it cannot be refilled.

Preparing for Use

To prepare the electrode to make pH measurements, follow this procedure:

- Remove the storage bottle from the electrode by first unscrewing the lid and then removing the bottle and lid. Thoroughly rinse the lower section of the probe, especially around the bulb-shaped tip, using distilled or deionized water.
- Connect the pH Sensor to your lab interface and run data-collection software. **Note:** Do not completely submerge the sensor. The handle is not waterproof.

When you are finished making measurements, rinse the electrode with distilled water. Slide the cap onto the electrode body, and then screw the cap onto the storage bottle so the tip of the electrode is immersed in the storage solution. When the probe is not being stored in the storage bottle, it can be stored for short periods of time (up to 24 hours) in pH 4 or pH 7 buffer solution.

It should never be stored in distilled water. It is a good idea to prepare a quantity of pH 4 buffer/KCl storage solution (see the section on Maintenance and Storage) and use it to replace lost solution.

Calibration

For many experiments, calibrating the pH Sensor is not required. We store a calibration equation on each pH sensor before shipping it, which is used as a default by our software.

For the most accurate measurements with this sensor, we recommend calibration. It is a simple process that takes only a few minutes.

Calibrating the pH Sensor Using Logger *Pro* 3

Before starting the calibration, obtain two buffer solutions and some distilled water for rinsing. pH 4 and pH 7 buffer solutions work well, but any two buffers will be suitable.

1. Connect the pH Sensor to your computer with a Vernier computer interface (LabPro, Go! Link, LabQuest Mini, LabQuest or LabQuest 2).
2. Choose Calibrate ▸ CH1: pH from the Experiment menu and then click Calibrate Now.
3. Remove the storage bottle from the pH Sensor, rinse the tip of the sensor with distilled water, and place the sensor in the first buffer solution so the tip is immersed.
4. Near the middle right of the calibration dialog box, you will see the potential output of the pH sensor, in volts. Type the pH of the buffer solution, in which the sensor rests, in the edit box. When the displayed voltage reading stabilizes, click Keep.
5. Rinse the pH sensor with distilled water and place it in the second buffer solution. The potential (voltage) will change. Type the pH of the second buffer solution in the second edit box. When the displayed voltage reading stabilizes, click Keep.
6. (Optional) If you wish to store the calibration on the sensor itself, click the Calibration Storage tab. If you wish to use the calibration only for the current experiment, skip to Step 10.
7. Click Set Sensor Calibration. Make sure the Default Page corresponds to your new calibration. Click Set.
8. Click Done. You will be prompted by the message, "Warning: You are about to change information in your sensor. Configuration data stored on the sensor will be lost. Pressing 'Write' will apply your changes to the sensor." Click Write.
9. Click Done to complete the calibration process.

You have now stored the calibration on the sensor itself. This new calibration will be used from now on, until you replace it by conducting another calibration or by reverting to the factory calibration.

You can set the pH sensor back to its factory calibration by following these steps:

1. Select Calibrate ▸ CH1: pH from the Experiment menu.
2. Click the Calibration Storage tab.
3. Click Set Sensor Factory Defaults.

Calibrating the pH Sensor Using a LabQuest or LabQuest 2

1. Connect the pH Sensor to your LabQuest. The pH reading will be displayed.
2. Choose Calibrate ▸ CH1: pH from the Sensors menu and tap Calibrate Now.
3. Remove the storage bottle from the pH Sensor, rinse the tip of the sensor with distilled water, and place the sensor in the first buffer solution so the tip is immersed.
4. Enter the pH of the buffer solution as the known value for Reading 1. When the voltage reading stabilizes, tap Keep.
5. Rinse the pH sensor with distilled water and place it in the second buffer solution.
6. In the Reading 2 field, enter the pH of the second buffer solution. When the voltage reading stabilizes, tap Keep.
7. (Optional) If you wish to store the calibration on the sensor itself, tap the Storage tab at the top of the screen. If you wish to use the calibration only for the current experiment, skip to Step 9.
8. On the Storage page, tap Save Calibration to Sensor. A message will appear: "Saving this calibration to the sensor will result in it being the new Custom Calibration 1". Tap OK to proceed.
9. Tap OK to complete the calibration process.

After you store a calibration to the pH Sensor, this new calibration will be used automatically, regardless of the interface to which the pH Sensor is connected.

You can set the pH sensor back to its factory calibration by following these steps:

1. Choose Calibrate ▸ CH1: pH from the Sensors menu.
2. Tap the Storage tab.
3. Tap Restore Sensor Factory Defaults.

pH Buffer Solutions

In order to calibrate a pH Sensor, or to confirm that a saved pH calibration is accurate, you should have a supply of pH buffer solutions that cover the range of pH values you will be measuring. We recommend buffer solutions of pH 4, 7, and 10.

- Vernier sells a pH buffer kit (order code PHB). The kit contains 4 tablets each of buffer pH 4, 7, and 10 and a small bottle of buffer preservative. Each tablet is added to 100 mL of distilled water to prepare respective pH buffer solutions.
- Flinn Scientific (www.flinnsci.com, Tel: 800-452-1261) sells a wide variety of buffer tablets and prepared buffer solutions.
- You can prepare your own buffer solutions using the following recipes:

pH 4.00	Add 2.0 mL of 0.1 M HCl to 1000 mL of 0.1 M potassium hydrogen phthalate.
pH 7.00	Add 582 mL of 0.1 M NaOH to 1000 mL of 0.1 M potassium dihydrogen phosphate.
pH 10.00	Add 214 mL of 0.1 M NaOH to 1000 mL of 0.05 M sodium bicarbonate.

Maintenance and Storage

Short-term storage (up to 24 hours): Place the electrode in pH 4 or pH 7 buffer solution.

Long-term storage (more than 24 hours): Store the electrode in a pH 4 buffer/KCl storage solution in the storage bottle. The pH Electrode is shipped in this solution. Vernier sells 500 mL bottles of pH Storage Solution (order code PH-SS), or you can prepare additional storage solution by adding 10 g of solid potassium chloride (KCl) to 100 mL of pH 4 buffer solution. Flinn Scientific (800-452-1261) sells a Buffer Solution Preservative (order code B0175) that can be added to this storage solution. By storing the electrode in this solution, the reference portion of the electrode is kept moist. Keeping the reference junction moist contributes to electrode longevity and retains electrode response time when the unit is placed back into service. If the electrode is inadvertently stored dry, immerse the unit in pH 4 buffer/KCl storage solution for a minimum of eight hours prior to service.

When testing a pH Sensor, it is best to measure a buffer solution because it is easier to determine if the sensor is reading correctly. Do not test your sensor by measuring distilled water. Distilled water can have a pH reading in the range of 5.5–7.0, due to varying amounts of dissolved carbon dioxide. Furthermore, due to a lack of ions, the pH values reported with the sensor in distilled water will be erratic.

If your pH Sensor is reading differently from the pH of a buffer solution (e.g., reads 6.7 in a buffer 7), you may simply need to calibrate the sensor.

If your readings are off by several pH values, the pH readings do not change when moved from one buffer solution to another different buffer, the sensor was stored dry, or the sensor's response seems slow, the problem may be more serious. A method called "shocking" can be used to revive pH electrodes. To shock your pH Sensor, perform the following:

1. Soak the pH Electrode for 4–8 hours in an HCl solution of 0.1 M–0.5 M.
2. Rinse off the electrode and soak the tip in pH 7 buffer for 30–60 minutes.
3. Rinse the electrode and test it with buffer solutions of known pH.

Occasionally, mold will grow in the pH 4 buffer/storage solution. Mold will not harm the electrode and can easily be removed using a mild detergent solution. Mold growth in the storage solution can be inhibited by adding a buffer preservative.

The pH sensor is designed to be used in aqueous solutions. The polycarbonate body of the sensor can be damaged by many organic solvents. In addition, do not use the sensor in solutions containing: perchlorates, silver ions, sulfide ions, biological samples with high concentrations of proteins, or Tris buffered solutions.[1] Do not use the sensor with hydrofluoric acid or in acid or base solutions with a concentration greater than 1.0 molar.

[1] Vernier offers a Tris-Compatible Flat pH Sensor which features a double junction electrode, so it can be used with proteins, sulfides, and Tris buffers. Order code FPH-BTA.

The electrode may be used to measure the pH of sodium hydroxide solutions with a concentration near 1.0 molar, but should not be left in this concentration of sodium hydroxide for periods longer than 5 minutes. Using or storing the electrode at very high temperatures (>80°C) or very low temperatures (near 0°C) can damage it beyond repair.

Specifications

Type		Sealed, gel-filled, epoxy body, Ag/AgCl
Response time		90% of final reading in 1 second in a buffer
Temperature range		5 to 80°C (readings not compensated)
Range		pH 0–14
Resolution		
13-bit (SensorDAQ)		0.0025 pH units
12-bit (LabPro, LabQuest, LabQuest 2, TI-Nspire™ Lab Cradle, LabQuest Mini, Go!Link, SBI, ULI II)		0.005 pH units
10-bit (CBL 2™)		0.02 pH units
Isopotential pH		pH 7 (point at which temperature has no effect)
Stored calibration values		
	slope	–3.838
	intercept	13.720

pH Sensor Accessories

Item	**Order Code**
Electrode Storage Solution, 500 mL	PH-SS
Buffer Tablets	PHB
Storage Solution Bottles, pkg of 5	BTL

Warranty

Vernier warrants this product to be free from defects in materials and workmanship for a period of five years from the date of shipment to the customer. This warranty does not cover damage to the product caused by abuse or improper use. Additionally, the warranty does not cover accidental breakage of the glass bulb of the pH Sensor.

Measure. Analyze. Learn.™
Vernier Software & Technology
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Rev. 5/8/2013

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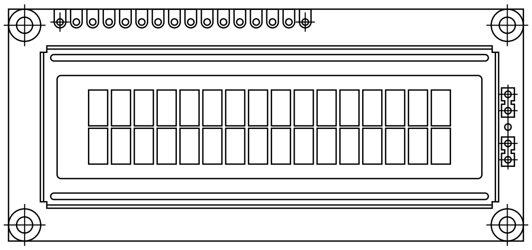
16 x 2 Character LCD



FEATURES

- Type: Character
- Display format: 16 x 2 characters
- Built-in controller: ST 7066 (or equivalent)
- Duty cycle: 1/16
- 5 x 8 dots includes cursor
- + 5 V power supply
- LED can be driven by pin 1, pin 2, or A and K
- N.V. optional for + 3 V power supply
- Optional: Smaller character size (2.95 mm x 4.35 mm)
- Material categorization: For definitions of compliance please see www.vishay.com/doc?99912

Pb-free

RoHS COMPLIANT

MECHANICAL DATA

ITEM	STANDARD VALUE	UNIT
Module Dimension	80.0 x 36.0 x 13.2 (max.)	mm
Viewing Area	66.0 x 16.0	
Dot Size	0.55 x 0.65	
Dot Pitch	0.60 x 0.70	
Mounting Hole	75.0 x 31.0	
Character Size	2.95 x 5.55	

ABSOLUTE MAXIMUM RATINGS

ITEM	SYMBOL	STANDARD VALUE			UNIT
		MIN.	TYP.	MAX.	
Power Supply	V_{DD} to V_{SS}	- 0.3	-	13	V
Input Voltage	V_I	V_{SS}	-	V_{DD}	

Note

- V_{SS} = 0 V, V_{DD} = 5.0 V

ELECTRICAL CHARACTERISTICS

ITEM	SYMBOL	CONDITION	STANDARD VALUE			UNIT
			MIN.	TYP.	MAX.	
Input Voltage	V_{DD}	V_{DD} = + 5 V	4.5	5.0	5.5	V
Supply Current	I_{DD}	V_{DD} = + 5 V	1.0	1.2	1.5	mA
Recommended LC Driving Voltage for Normal Temperature Version Module	V_{DD} to V_0	- 20 °C	-	-	5.2	V
		0 °C	-	-	-	
		25 °C	-	3.7	-	
		50 °C	-	-	-	
		70 °C	3.1	-	-	
LED Forward Voltage	V_F	25 °C	-	4.2	4.6	V
LED Forward Current - Array	I_F	25 °C	-	100	-	mA
LED Forward Current - Edge			-	20	40	
EL Power Supply Current	I_{EL}	V_{EL} = 110 V_{AC}, 400 Hz	-	-	5.0	mA

DISPLAY CHARACTER ADDRESS CODE

Display Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
DD RAM Address	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F
DD RAM Address	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F

For technical questions, contact: displays@vishay.com

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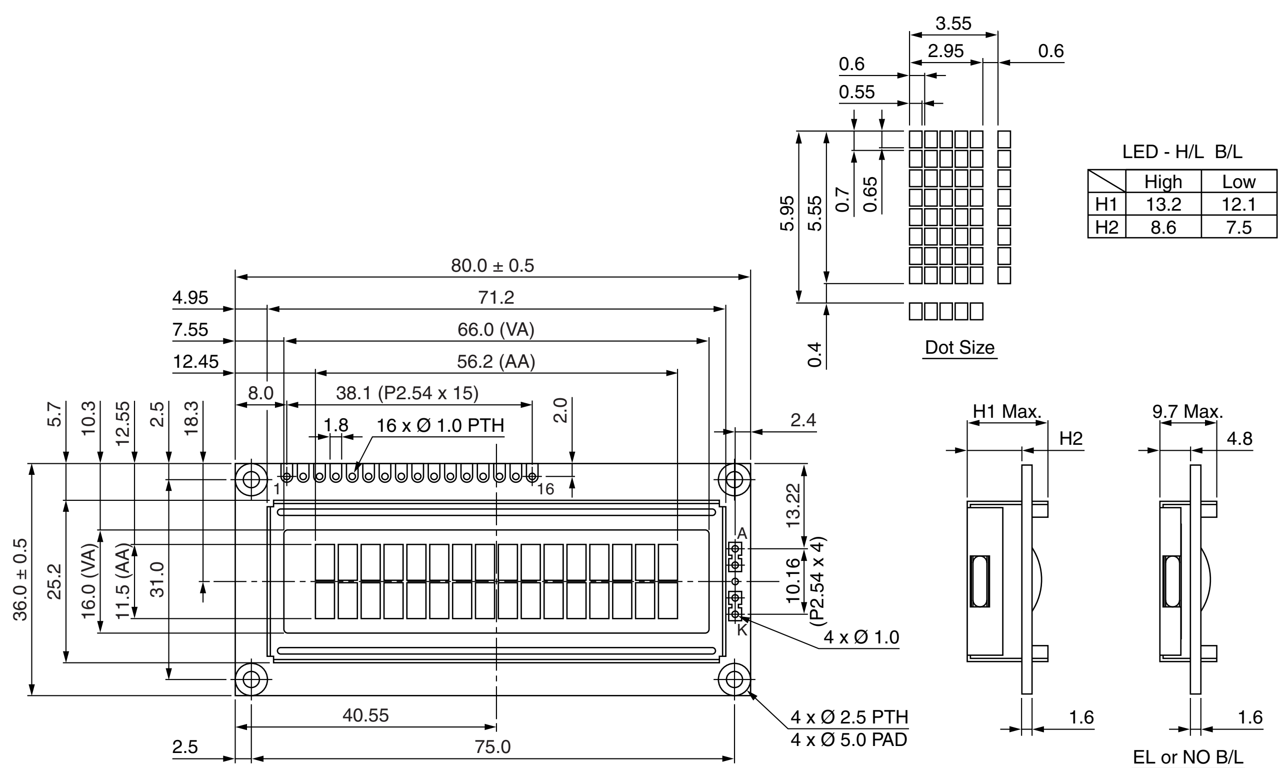
INTERFACE PIN FUNCTION

PIN NO.	SYMBOL	FUNCTION
1	V_{SS}	Ground
2	V_{DD}	Supply voltage for logic
3	V_0	Operating voltage for LCD
4	RS	H: Data/L: Instruction code
5	$R/\overline{W}$	H: Read (MPU → Module)/L: Write (MPU → Module)
6	E	H → L chip enable signal
7	DB0	Data bus line
8	DB1	Data bus line
9	DB2	Data bus line
10	DB3	Data bus line
11	DB4	Data bus line
12	DB5	Data bus line
13	DB6	Data bus line
14	DB7	Data bus line
15	A	Supply power for LED+
16	R	Supply power for Red-
17	G	Supply power for Green-
18	B	Supply power for Blue-

DIMENSIONS in millimeters



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1.Module Classification Information

LCD -016 N 002 B -C F H -ET

① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

1. Brand：Vishay Intertechnology, Inc.
2. Horizontal Format: 16 characters
3. Display Type：N→Character Type, H→Graphic Type
4. Vertical Format: 2 Lines
5. Model serials no.: B
6. Backlight Type：

6. Backlight Type：	N→Without backlight	A→LED, Amber
	B→EL, Blue green	R→LED, Red
	D→EL, Green	O→LED, Orange
	W→EL, White	G→LED, Green
	F→CCFL, White	T→LED, White
	Y→LED, Yellow Green	C→LED, RGB color
7. LCD Mode：	B→TN Positive, Gray	T→FSTN Negative
	N→TN Negative,	
	G→STN Positive, Gray	
	Y→STN Positive, Yellow Green	
	M→STN Negative, Blue	
	F→FSTN Positive	
8. LCD Polarize Type/ Temperature range/ View direction	A→Reflective, N.T, 6:00	H→Transflective, W.T,6:00
	D→Reflective, N.T, 12:00	K→Transflective, W.T,12:00
	G→Reflective, W. T, 6:00	C→Transmissive, N.T,6:00
	J→Reflective, W. T, 12:00	F→Transmissive, N.T,12:00
	B→Transflective, N.T,6:00	I→Transmissive, W. T, 6:00
	E→Transflective, N.T.12:00	L→Transmissive, W.T,12:00
9. Special Code	ET : English and European standard font Compliant with the ROHS Directions and regulations	

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2.Precautions in use of LCD Modules

(1)Avoid applying excessive shocks to the module or making any alterations or modifications to it.
(2)Don't make extra holes on the printed circuit board, modify its shape or change the components of LCD module.
(3)Don't disassemble the LCM.
(4)Don't operate it above the absolute maximum rating.
(5)Don't drop, bend or twist LCM.
(6)Soldering: only to the I/O terminals.
(7)Storage: please storage in anti-static electricity container and clean environment.

3.General Specification

Item	Dimension	Unit
Number of Characters	16 characters x 2 Lines	—
Module dimension	80.0 x 36.0 x 13.2(MAX)	mm
View area	66.0 x 16.0	mm
Active area	56.2 x 11.5	mm
Dot size	0.55 x 0.65	mm
Dot pitch	0.60 x 0.70	mm
Character size	2.95 x 5.55	mm
Character pitch	3.55 x 5.95	mm
LCD type	FSTN Positive, Transflective	
Duty	1/16	
View direction	6 o'clock	
Backlight Type	LED, Triple-color	

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4.Absolute Maximum Ratings

Item	Symbol	Min	Typ	Max	Unit
Operating Temperature	T_{OP}	-20	—	+70	℃
Storage Temperature	T_{ST}	-30	—	+80	℃
Input Voltage	V_I	V_{SS}	—	V_{DD}	V
Supply Voltage For Logic	V_{DD}-V_{SS}	-0.3	—	7	V
Supply Voltage For LCD	V_{DD}-V_0	-0.3	—	13	V

5.Electrical Characteristics

Item	Symbol	Condition	Min	Typ	Max	Unit
Supply Voltage For Logic	V_{DD}-V_{SS}	—	4.5	5.0	5.5	V
Supply Voltage For LCD	V_{DD}-V_0	Ta=-20℃	—	—	5.2	V
		Ta=25℃	—	3.7	—	V
		Ta=70℃	3.1	—	—	V
Input High Volt.	V_{IH}	—	0.7	—	V_{DD}	V
Input Low Volt.	V_{IL}	—	0	—	0.6	V
Output High Volt.	V_{OH}	—	3.9	—	V_{DD}	V
Output Low Volt.	V_{OL}	—	0	—	0.4	V
Supply Current	I_{DD}	V_{DD}=5V	1.0	1.2	1.5	mA

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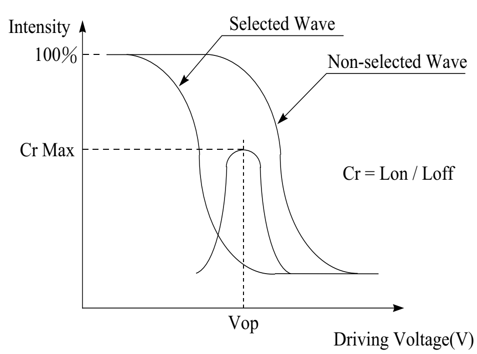
6.Optical Characteristics

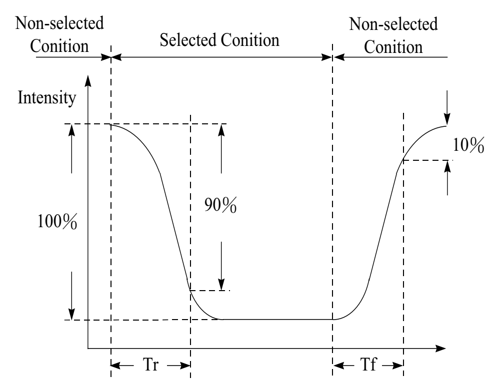
Item	Symbol	Condition	Min	Typ	Max	Unit
View Angle	(V) θ	CR≧5	30	—	60	deg
	(H) φ	CR≧5	-45	—	45	deg
Contrast Ratio	CR	—	—	5	—	—
Response Time	T rise	—	—	150	200	ms
	T fall	—	—	150	200	ms

Definition of Operation Voltage (Vop)



[positive type]

Definition of Response Time (Tr , Tf)



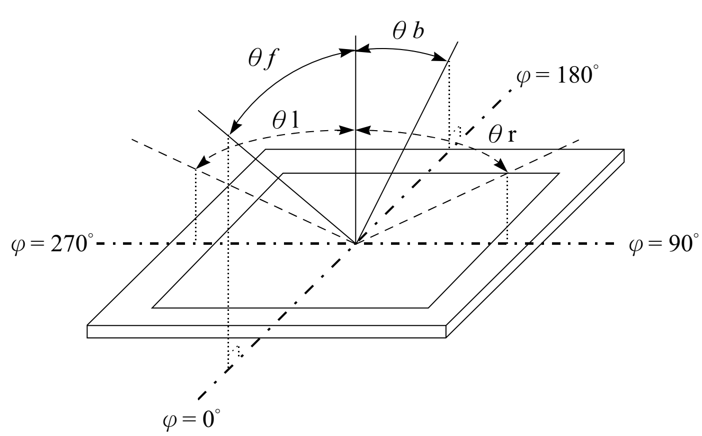
[positive type]

Conditions :

Operating Voltage : Vop   Viewing Angle(θ ， φ) : 0° ， 0°

Frame Frequency : 64 HZ   Driving Waveform : 1/N duty , 1/a bias

Definition of viewing angle(CR≧2)



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7.Interface Pin Function

Pin No.	Symbol	Level	Description
1	V_{SS}	0V	Ground
2	V_{DD}	5.0V	Supply Voltage for logic
3	VO	(Variable)	Operating voltage for LCD
4	RS	H/L	H: DATA, L: Instruction code
5	R/W	H/L	H: Read(MPU→Module) L: Write(MPU→Module)
6	E	H,H→L	Chip enable signal
7	DB0	H/L	Data bus line
8	DB1	H/L	Data bus line
9	DB2	H/L	Data bus line
10	DB3	H/L	Data bus line
11	DB4	H/L	Data bus line
12	DB5	H/L	Data bus line
13	DB6	H/L	Data bus line
14	DB7	H/L	Data bus line
15	A	—	Supply power for LED +
16	R	—	Supply power for Red -
17	G		Supply power for Green -
18	B		Supply power for Blue -

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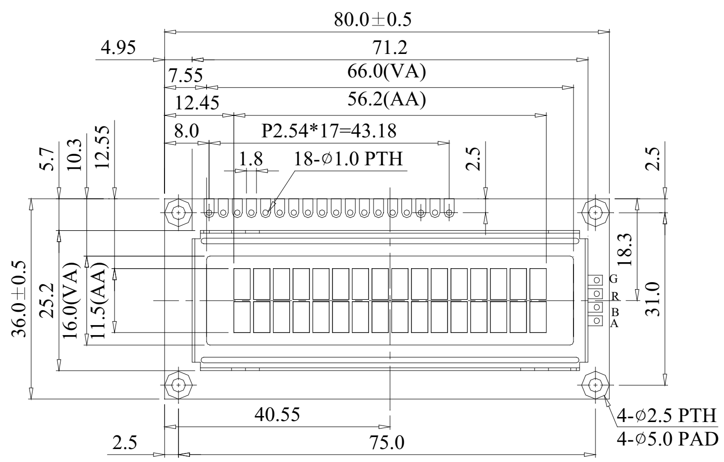
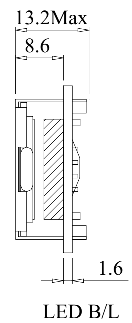
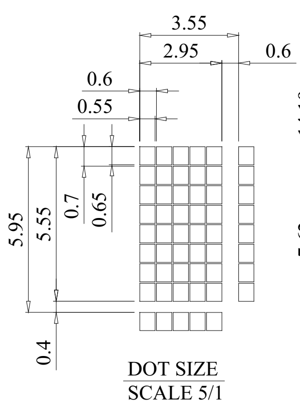
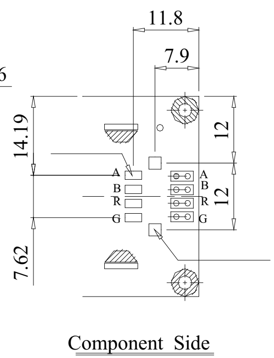
8.Contour Drawing &Block Diagram



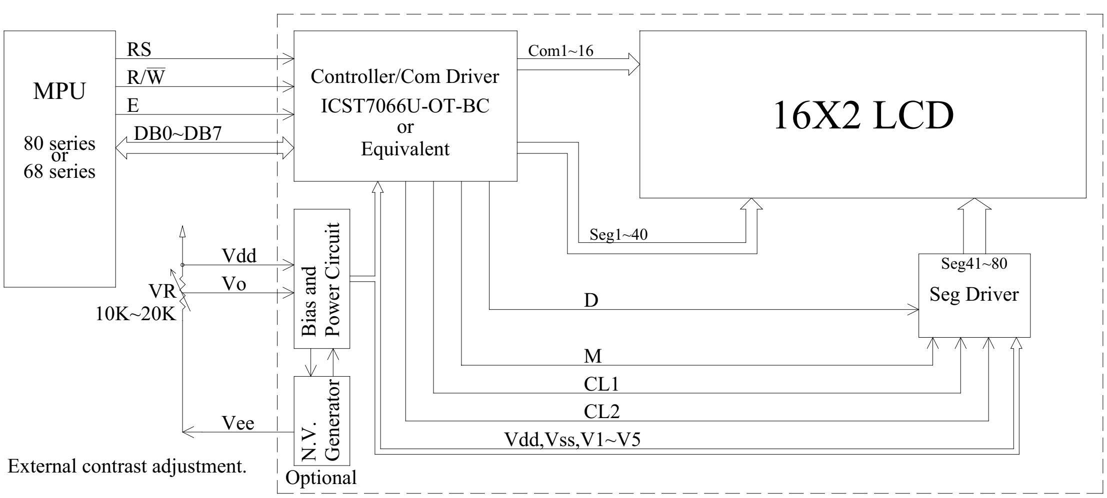


1	Vss
2	Vdd
3	Vo
4	RS
5	R/W
6	E
7	DB0
8	DB1
9	DB2
10	DB3
11	DB4
12	DB5
13	DB6
14	DB7
15	A
16	R
17	G
18	B





The non-specified tolerance of dimension is ¡Ó0.3 mm .



Character located	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
DDRAM address	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F
DDRAM address	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F

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9.Function Description

The LCD display Module is built in a LSI controller, the controller has two 8-bit registers, an instruction register (IR) and a data register (DR).

The IR stores instruction codes, such as display clear and cursor shift, and address information for display data RAM (DDRAM) and character generator (CGRAM). The IR can only be written from the MPU. The DR temporarily stores data to be written or read from DDRAM or CGRAM. When address information is written into the IR, then data is stored into the DR from DDRAM or CGRAM. By the register selector (RS) signal, these two registers can be selected.

RS	R/W	Operation
0	0	IR write as an internal operation (display clear, etc.)
0	1	Read busy flag (DB7) and address counter (DB0 to DB7)
1	0	Write data to DDRAM or CGRAM (DR to DDRAM or CGRAM)
1	1	Read data from DDRAM or CGRAM (DDRAM or CGRAM to DR)

Busy Flag (BF)

When the busy flag is 1, the controller LSI is in the internal operation mode, and the next instruction will not be accepted. When RS=0 and R/W=1, the busy flag is output to DB7. The next instruction must be written after ensuring that the busy flag is 0.

Address Counter (AC)

The address counter (AC) assigns addresses to both DDRAM and CGRAM

Display Data RAM (DDRAM)

This DDRAM is used to store the display data represented in 8-bit character codes. Its extended capacity is 80x8 bits or 80 characters. Below figure is the relationship between DDRAM addresses and positions on the liquid crystal display.

High bits (AC6–AC4) Low bits (AC3–AC0)

AC (hexadecimal)

AC6	AC5	AC4	AC3	AC2	AC1	AC0

Example: DDRAM addresses 4E

1	0	0	1	1	1	0

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Display position DDRAM address

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F
40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F

2-Line by 16-Character Display

Character Generator ROM (CGROM)

The CGROM generate 5x8 dot or 5x10 dot character patterns from 8-bit character codes. See Table 2.

Character Generator RAM (CGRAM)

In CGRAM, the user can rewrite character by program. For 5x8 dots, eight character patterns can be written, and for 5x10 dots, four character patterns can be written.

Write into DDRAM the character code at the addresses shown as the left column of table 1. To show the character patterns stored in CGRAM.

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Relationship between CGRAM Addresses, Character Codes (DDRAM) and Character patterns

Table 1.

For 5 * 8 dot character patterns

Character Codes (DDRAM data) 7 6 5 4 3 2 1 0 (High … Low)	CGRAM Address 5 4 3 2 1 0 (High … Low)	Character Patterns (CGRAM data) 7 6 5 4 3 2 1 0 (High … Low)	
0 0 0 0 * 0 0 0	0 0 0 0 0 0	* * * ■ ■ ■ ■ 0	Character pattern(1)
	0 0 0 0 0 1	* * * ■ 0 0 0 ■	
	0 0 0 0 1 0	* * * ■ 0 0 0 ■	
	0 0 0 0 1 1	* * * ■ ■ ■ ■ 0	
	0 0 0 1 0 0	* * * ■ 0 ■ 0 0	
	0 0 0 1 0 1	* * * ■ 0 0 ■ 0	
	0 0 0 1 1 0	* * * ■ 0 0 0 ■	
	0 0 0 1 1 1	* * * 0 0 0 0 0	Cursor pattern
0 0 0 0 * 0 0 1	0 0 1 0 0 0	* * * ■ 0 0 0 ■	Character pattern(2)
	0 0 1 0 0 1	* * * 0 ■ 0 ■ 0	
	0 0 1 0 1 0	* * * ■ ■ ■ ■ ■	
	0 0 1 0 1 1	* * * 0 0 ■ 0 0	
	0 0 1 1 0 0	* * * ■ ■ ■ ■ ■	
	0 0 1 1 0 1	* * * 0 0 ■ 0 0	
	0 0 1 1 1 0	* * * 0 0 ■ 0 0	
	0 0 1 1 1 1	* * * 0 0 0 0 0	Cursor pattern
	0 0 0	* * *	
	0 0 1		
0 0 0 0 * 1 1 1	1 1 1 1 0 0		
	1 0 1		
	1 1 0		
	1 1 1	* * *	

For 5 * 10 dot character patterns

Character Codes (DDRAM data) 7 6 5 4 3 2 1 0 (High … Low)	CGRAM Address 5 4 3 2 1 0 (High … Low)	Character Patterns (CGRAM data) 7 6 5 4 3 2 1 0 (High … Low)	
0 0 0 0 * 0 0 0	0 0 0 0 0 0	* * * 0 0 0 0 0	Character pattern
	0 0 0 0 0 1	* * * 0 0 0 0 0	
	0 0 0 0 1 0	* * * ■ 0 ■ ■ 0	
	0 0 0 0 1 1	* * * ■ ■ 0 0 ■	
	0 0 0 1 0 0	* * * ■ 0 0 0 ■	
	0 0 0 1 0 1	* * * ■ 0 0 0 ■	
	0 0 0 1 1 0	* * * ■ ■ ■ ■ 0	
	0 0 0 1 1 1	* * * ■ 0 0 0 0	
	0 0 1 0 0 0	* * * ■ 0 0 0 0	
	0 0 1 0 0 1	* * * ■ 0 0 0 0	
	0 0 1 0 1 0	* * * 0 0 0 0 0	Cursor pattern
	1 1 1 1	* * * * * * * *	

■ : " High "

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10. Character Generator ROM Pattern

Table.2

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11.Instruction Table

Instruction	Instruction Code										Description	Execution time (fosc=270Khz)
	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		
Clear Display	0	0	0	0	0	0	0	0	0	1	Write “00H” to DDRAM and set DDRAM address to “00H” from AC	1.53ms
Return Home	0	0	0	0	0	0	0	0	1	—	Set DDRAM address to “00H” from AC and return cursor to its original position if shifted. The contents of DDRAM are not changed.	1.53ms
Entry Mode Set	0	0	0	0	0	0	0	1	I/D	SH	Assign cursor moving direction and enable the shift of entire display.	39 μ s
Display ON/OFF Control	0	0	0	0	0	0	1	D	C	B	Set display (D), cursor (C), and blinking of cursor (B) on/off control bit.	39 μ s
Cursor or Display Shift	0	0	0	0	0	1	S/C	R/L	—	—	Set cursor moving and display shift control bit, and the direction, without changing of DDRAM data.	39 μ s
Function Set	0	0	0	0	1	DL	N	F	—	—	Set interface data length (DL:8-bit/4-bit), numbers of display line (N:2-line/1-line)and, display font type (F:5x11 dots/5x8 dots)	39 μ s
Set CGRAM Address	0	0	0	1	AC5	AC4	AC3	AC2	AC1	AC0	Set CGRAM address in address counter.	39 μ s
Set DDRAM Address	0	0	1	AC6	AC5	AC4	AC3	AC2	AC1	AC0	Set DDRAM address in address counter.	39 μ s
Read Busy Flag and Address	0	1	BF	AC6	AC5	AC4	AC3	AC2	AC1	AC0	Whether during internal operation or not can be known by reading BF. The contents of address counter can also be read.	0 μ s
Write Data to RAM	1	0	D7	D6	D5	D4	D3	D2	D1	D0	Write data into internal RAM (DDRAM/CGRAM).	43 μ s
Read Data from RAM	1	1	D7	D6	D5	D4	D3	D2	D1	D0	Read data from internal RAM (DDRAM/CGRAM).	43 μ s

* ”—”：don’t care

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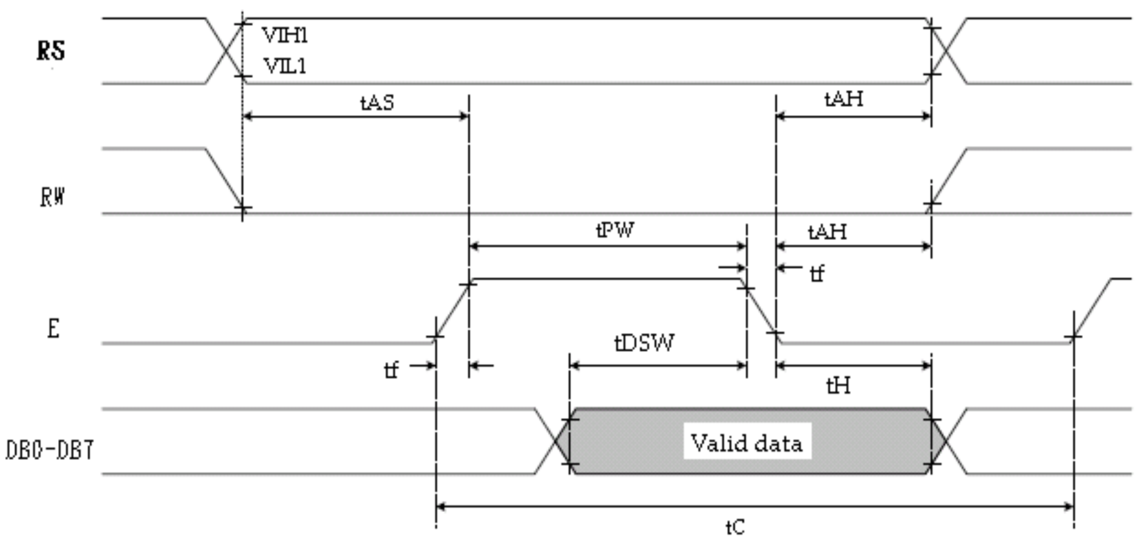
12.Timing Characteristics

12.1 Write Operation

- Writing data from MPU



Ta=25℃, VDD=5.0V

Item	Symbol	Min	Typ	Max	Unit
Enable cycle time	T_C	1200	—	—	ns
Enable pulse width	T_{PW}	140	—	—	ns
Enable rise/fall time	T_R,T_F	—	—	25	ns
Address set-up time (RS, R/W to E)	t_{AS}	0	—	—	ns
Address hold time	t_{AH}	10	—	—	ns
Data set-up time	t_{DSW}	40	—	—	ns
Data hold time	t_H	10	—	—	ns

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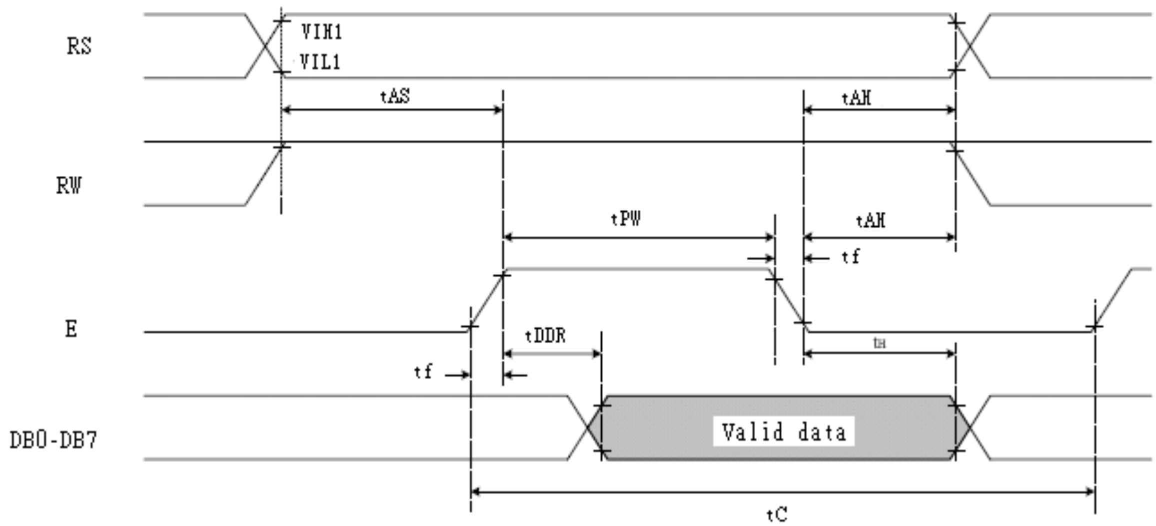
12.2 Read Operation

- Reading data from ST7066U



Ta=25℃, VDD=5V

Item	Symbol	Min	Typ	Max	Unit
Enable cycle time	T_C	1200	—	—	ns
Enable pulse width (high level)	T_{PW}	140	—	—	ns
Enable rise/fall time	T_R,T_F	—	—	25	ns
Address set-up time (RS, R/W to E)	t_{AS}	0	—	—	ns
Address hold time	t_{AH}	10	—	—	ns
Data delay time	t_{DDR}	—	—	100	ns
Data hold time	t_H	10	—	—	ns

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13.Initializing of LCM

Power on

Wait for more than 40 ms after VDD rises to 4.5 V

BF can not be checked before this instruction.

Function set

RS	R/W̄	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	1	1	*	*	*	*

Wait for more than 39us

BF can not be checked before this instruction.

Function set

RS	R/W̄	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	1	0	*	*	*	*
0	0	N	F	*	*	*	*	*	*

Wait for more than 39 µs

BF can not be checked before this instruction.

Function set

RS	R/W̄	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	1	0	*	*	*	*
0	0	N	F	*	*	*	*	*	*

Wait for more than 37us

Display ON/OFF control

RS	R/W̄	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	0	*	*	*	*
0	0	1	D	C	B	*	*	*	*

Wait for more than 37 µs

Display Clear

RS	R/W̄	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	0	*	*	*	*
0	0	0	0	0	1	*	*	*	*

Wait for more than 1.53ms

Entry Mode Set

RS	R/W̄	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	0	*	*	*	*
0	0	0	1	I/D	SH	*	*	*	*

Initialization ends

4-Bit Ineterface

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Power on

↓

Wait for more than 40 ms after V_{DD} rises to 4.5 V

↓

BF can not be checked before this instruction.

Function set

RS	R/$\overline{W}$	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	1	1	N	F	*	*

↓

Wait for more than 39us

↓

BF can not be checked before this instruction.

Function set

RS	R/$\overline{W}$	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	1	1	N	F	*	*

↓

Wait for more than 37us

↓

Display ON/OFF control

RS	R/$\overline{W}$	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	0	1	B	C	D

↓

Wait for more than 37 µs

↓

Display Clear

RS	R/$\overline{W}$	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	0	0	0	0	1

↓

Wait for more than 1.53ms

↓

Entry Mode Set

RS	R/$\overline{W}$	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	0	0	1	I/D	S

↓

Initialization ends

8-Bit Ineterface

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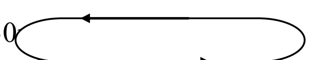
14.Reliability

Content of Reliability Test (wide temperature, -20℃~70℃)

Environmental Test			
Test Item	**Content of Test**	**Test Condition**	**Note**
High Temperature storage	Endurance test applying the high storage temperature for a long time.	80℃ 200hrs	2
Low Temperature storage	Endurance test applying the high storage temperature for a long time.	-30℃ 200hrs	1,2
High Temperature Operation	Endurance test applying the electric stress (Voltage & Current) and the thermal stress to the element for a long time.	70℃ 200hrs	——
Low Temperature Operation	Endurance test applying the electric stress under low temperature for a long time.	-20℃ 200hrs	1
High Temperature/ Humidity Operation	The module should be allowed to stand at 60 ℃,90%RH max For 96hrs under no-load condition excluding the polarizer, Then taking it out and drying it at normal temperature.	60℃,90%RH 96hrs	1,2
Thermal shock resistance	The sample should be allowed stand the following 10 cycles of operation -20℃ 25℃ 70℃  30 1 cycle	-20℃/70℃ 10 cycles	——
Vibration test	Endurance test applying the vibration during transportation and using.	Total fixed amplitude : 1.5mm Vibration Frequency : 10~55Hz One cycle 60 seconds to 3 directions of X,Y,Z for Each 15 minutes	3
Static electricity test	Endurance test applying the electric stress to the terminal.	VS=800V,RS=1.5k Ω CS=100pF 1 time	——

Note1: No dew condensation to be observed.

Note2: The function test shall be conducted after 4 hours storage at the normal Temperature and humidity after remove from the test chamber.

Note3: Vibration test will be conducted to the product itself without putting it in a container.

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15.Backlight Information

Specification

PARAMETER	SYMBOL		MIN	TYP	MAX	UNIT	TEST CONDITION
Supply Current	ILED	R	20	24	28	mA	V=5.0V
		G	25	30	34		
		B	25	30	34		
Supply Voltage	V		4.9	5.0	5.1	V	—
Reverse Voltage	VR		—	7.0	—	V	—
Luminous Intensity	IV	R	32	40	—	CD/M^2	ILED(red)=24mA
		G	140	180			ILED(green)=30mA
		B	22	28			ILED(blue)=30mA
Wave Length	λ	R	620	625	630	nm	—
		G	515	520	525		
		B	465	470	475		
Life Time	R		80K	100K		Hr.	ILED≦15mA For each LED Lamp
	G		40K	50K			
	B		40K	50K			
Color	Red, Green, Blue						

Note:

1. The LED B/L of "*triple color*" is designed for voltage driving, user have to follow The drive voltage that can make driving current in safety range (current between minimum and maximum).
2. Owing to having 3 chips in one LED lamp, which caused many combinations of different wave length. This situation will caused wave length shifting while driving 2 colors or more in the same time.
3. The luminous intensity is measured on B/L surface only.

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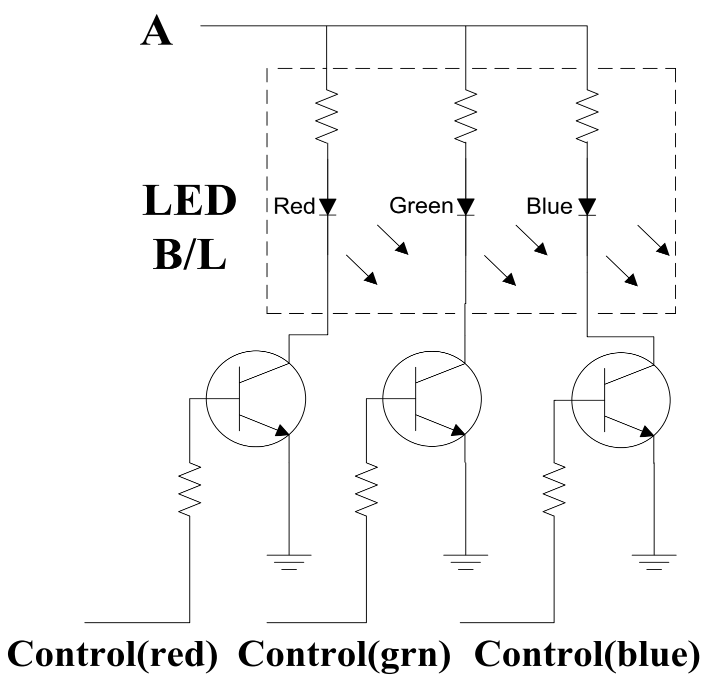
1 Backlight Drive Method



The driving circuit of suggestion is showed as above, owing to B/L being designed In parallel mode, so user can use transistor、FET or TRIC to control.

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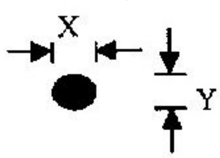
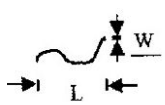
16. Inspection specification

<table>
<tr><th>NO</th><th>Item</th><th>Criterion</th><th>AQL</th></tr>
<tr><td>01</td><td>Electrical Testing</td><td>1.1 Missing vertical, horizontal segment, segment contrast defect.
1.2 Missing character , dot or icon.
1.3 Display malfunction.
1.4 No function or no display.
1.5 Current consumption exceeds product specifications.
1.6 LCD viewing angle defect.
1.7 Mixed product types.
1.8 Contrast defect.</td><td>0.65</td></tr>
<tr><td>02</td><td>Black or white spots on LCD (display only)</td><td>2.1 White and black spots on display ≦0.25mm, no more than three white or black spots present.
2.2 Densely spaced: No more than two spots or lines within 3mm</td><td>2.5</td></tr>
<tr><td rowspan="2">03</td><td rowspan="2">LCD black spots, white spots, contamination (non-display)</td><td>3.1 Round type : As following drawing
Φ=(x + y) / 2


<table>
<tr><th>SIZE</th><th>Acceptable Q TY</th></tr>
<tr><td>Φ ≦0.10</td><td>Accept no dense</td></tr>
<tr><td>0.10＜Φ ≦0.20</td><td>2</td></tr>
<tr><td>0.20＜Φ ≦0.25</td><td>1</td></tr>
<tr><td>0.25＜Φ</td><td>0</td></tr>
</table></td><td>2.5</td></tr>
<tr><td>3.2 Line type : (As following drawing)


<table>
<tr><th>Length</th><th>Width</th><th>Acceptable Q TY</th></tr>
<tr><td>---</td><td>W≦0.02</td><td>Accept no dense</td></tr>
<tr><td>L≦3.0</td><td>0.02＜W≦0.03</td><td rowspan="2">2</td></tr>
<tr><td>L≦2.5</td><td>0.03＜W≦0.05</td></tr>
<tr><td>---</td><td>0.05＜W</td><td>As round type</td></tr>
</table></td><td>2.5</td></tr>
<tr><td>04</td><td>Polarizer bubbles</td><td>If bubbles are visible, judge using black spot specifications, not easy to find, must check in specify direction.
<table>
<tr><th>Size Φ</th><th>Acceptable Q TY</th></tr>
<tr><td>Φ ≦0.20</td><td>Accept no dense</td></tr>
<tr><td>0.20＜Φ ≦0.50</td><td>3</td></tr>
<tr><td>0.50＜Φ ≦1.00</td><td>2</td></tr>
<tr><td>1.00＜Φ</td><td>0</td></tr>
<tr><td>Total Q TY</td><td>3</td></tr>
</table></td><td>2.5</td></tr>
</table>

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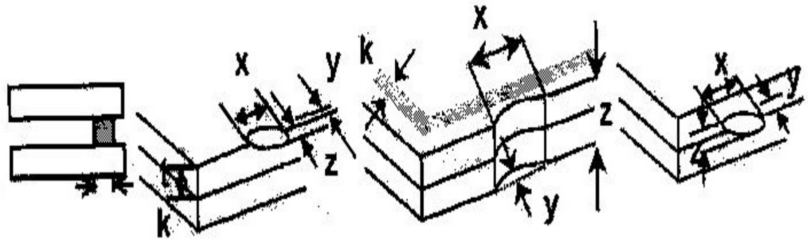
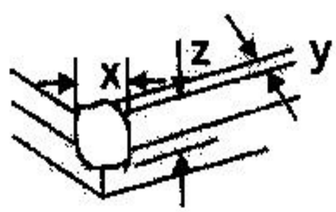
<table>
<tr><th>NO</th><th>Item</th><th>Criterion</th><th>AQL</th></tr>
<tr><td>05</td><td>Scratches</td><td>Follow NO.3 LCD black spots, white spots, contamination</td><td></td></tr>
<tr><td>06</td><td>Chipped glass</td><td>
Symbols Define:
x: Chip length   y: Chip width   z: Chip thickness
k: Seal width   t: Glass thickness   a: LCD side length
L: Electrode pad length:

6.1 General glass chip :
6.1.1 Chip on panel surface and crack between panels:


<table>
<tr><th>z: Chip thickness</th><th>y: Chip width</th><th>x: Chip length</th></tr>
<tr><td>Z≦1/2t</td><td>Not over viewing area</td><td>x≦1/8a</td></tr>
<tr><td>1/2t<z≦2t</td><td>Not exceed 1/3k</td><td>x≦1/8a</td></tr>
</table>
⊙If there are 2 or more chips, x is total length of each chip.

6.1.2 Corner crack:


<table>
<tr><th>z: Chip thickness</th><th>y: Chip width</th><th>x: Chip length</th></tr>
<tr><td>Z≦1/2t</td><td>Not over viewing area</td><td>x≦1/8a</td></tr>
<tr><td>1/2t<z≦2t</td><td>Not exceed 1/3k</td><td>x≦1/8a</td></tr>
</table>
⊙If there are 2 or more chips, x is the total length of each chip.
</td><td>2.5</td></tr>
</table>

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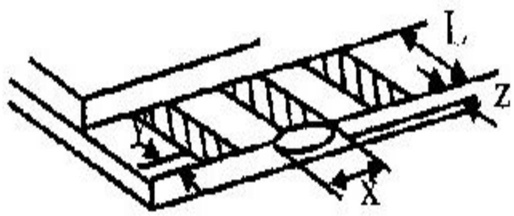
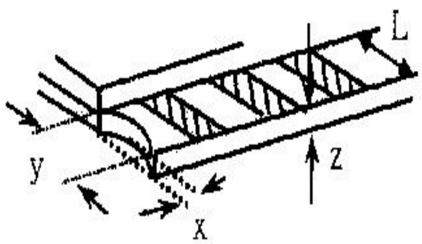
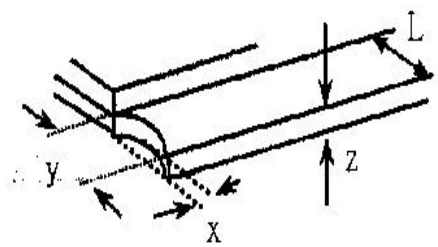
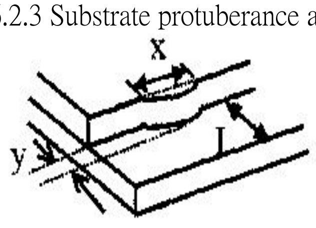
<table>
<tr><th>NO</th><th>Item</th><th>Criterion</th><th>AQL</th></tr>
<tr><td>06</td><td>Glass crack</td><td>
Symbols :
x: Chip length y: Chip width z: Chip thickness
k: Seal width t: Glass thickness a: LCD side length
L: Electrode pad length
6.2 Protrusion over terminal :
6.2.1 Chip on electrode pad :


<table>
<tr><th>y: Chip width</th><th>x: Chip length</th><th>z: Chip thickness</th></tr>
<tr><td>y≦0.5mm</td><td>x≦1/8a</td><td>0 < z ≦ t</td></tr>
</table>
6.2.2 Non-conductive portion:




<table>
<tr><th>y: Chip width</th><th>x: Chip length</th><th>z: Chip thickness</th></tr>
<tr><td>y≦ L</td><td>x≦1/8a</td><td>0 < z ≦ t</td></tr>
</table>
⊙If the chipped area touches the ITO terminal, over 2/3 of the ITO must remain and be inspected according to electrode terminal specifications.
⊙If the product will be heat sealed by the customer, the alignment mark not be damaged.
6.2.3 Substrate protuberance and internal crack.


<table>
<tr><th>y: width</th><th>x: length</th></tr>
<tr><td>y≦1/3L</td><td>x ≦ a</td></tr>
</table>
</td><td>2.5</td></tr>
</table>

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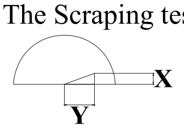
NO	Item	Criterion	AQL
07	Cracked glass	The LCD with extensive crack is not acceptable.	2.5
08	Backlight elements	8.1 Illumination source flickers when lit. 8.2 Spots or scratched that appear when lit must be judged. Using LCD spot, lines and contamination standards. 8.3 Backlight doesn' t light or color wrong.	0.65 2.5 0.65
09	Bezel	9.1 Bezel may not have rust, be deformed or have fingerprints, stains or other contamination. 9.2 Bezel must comply with job specifications.	2.5 0.65
10	PCB、COB	10.1 COB seal may not have pinholes larger than 0.2mm or contamination. 10.2 COB seal surface may not have pinholes through to the IC. 10.3 The height of the COB should not exceed the height indicated in the assembly diagram. 10.4 There may not be more than 2mm of sealant outside the seal area on the PCB. And there should be no more than three places. 10.5 No oxidation or contamination PCB terminals. 10.6 Parts on PCB must be the same as on the production characteristic chart. There should be no wrong parts, missing parts or excess parts. 10.7 The jumper on the PCB should conform to the product characteristic chart. 10.8 If solder gets on bezel tab pads, LED pad, zebra pad or screw hold pad, make sure it is smoothed down. 10.9 The Scraping testing standard for Copper Coating of PCB  **X * Y<=2mm²**	2.5 2.5 0.65 2.5 2.5 0.65 0.65 2.5 2.5
11	Soldering	11.1 No un-melted solder paste may be present on the PCB. 11.2 No cold solder joints, missing solder connections, oxidation or icicle. 11.3 No residue or solder balls on PCB. 11.4 No short circuits in components on PCB.	2.5 2.5 2.5 0.65

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NO	Item	Criterion	AQL
12	General appearance	12.1 No oxidation, contamination, curves or, bends on interface Pin (OLB) of TCP.	2.5
		12.2 No cracks on interface pin (OLB) of TCP.	0.65
		12.3 No contamination, solder residue or solder balls on product.	2.5
		12.4 The IC on the TCP may not be damaged, circuits.	2.5
		12.5 The uppermost edge of the protective strip on the interface pin must be present or look as if it causes the interface pin to sever.	2.5
		12.6 The residual rosin or tin oil of soldering (component or chip component) is not burned into brown or black color.	2.5
		12.7 Sealant on top of the ITO circuit has not hardened.	2.5
		12.8 Pin type must match type in specification sheet.	0.65
		12.9 LCD pin loose or missing pins.	0.65
		12.10 Product packaging must the same as specified on packaging specification sheet.	0.65
		12.11 Product dimension and structure must conform to product specification sheet.	0.65

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