

# ZETTLER DISPLAYS

## SPECIFICATIONS FOR LIQUID CRYSTAL DISPLAY

CUSTOMER APPROVAL			
※ PART NO. : <u>AQM1602Y-NLW-FBW(ZETTLER DISPLAYS) VER1.0</u>			
APPROVAL		COMPANY CHOP	
CUSTOMER COMMENTS			

ZETTLER DISPLAYS ENGINEERING APPROVAL		
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**REVISION RECORD**

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## 1.0 GENERAL SPECS

1. Display Format	16*2 Character
2. Power Supply	3.3V
3. Overall Module Size	43.6mm(W) x 25.47mm(H) x max 6.0mm(D)
4. Viewing Area(W*H)	38.2mm(W) x 12.82mm(H)
5. Dot Size (W*H)	0.34mm(W) x 0.50mm(H)
6. Dot Pitch (W*H)	0.38mm(W) x 0.58mm(H)
7. Character Size (W*H)	1.86mm(W) x 4.56mm(H)
8. Character Pitch (W*H)	2.26mm(W) x 5.26mm(H)
9. Viewing Direction	6 O'Clock
10. Driving Method	1/17Duty, 1/5Bias
11. Controller IC	ST7032I-0D or compatible
12. LC Fluid Options	FSTN/Negative/Transmissive
13. Backlight Options	White LED /Side
14. Operating temperature	-20°C ~ 70°C
15. Storage temperature	-30°C ~ 80°C
16. RoHS	RoHS compliant

## 2.0 ABSOLUTE MAXIMUM RATINGS

Item	Symbol	Min	Typ	Max	Unit
Operating temperature	Top	-20	-	70	°C
Storage temperature	Tst	-30	-	80	°C
Input voltage	Vin	0.3	--	Vdd+0.3	V
Supply voltage for logic	Vdd- Vss	-0.3	-	6.0	V
Supply voltage for LCD driving	V0-Vss	Vss-0.3	-	7.0-Vss	V

## 3.0 ELECTRICAL CHARACTERISTICS

### 3.1 Electrical Characteristics Of LCM

Item	Symbol	Condition	Min	Typ	Max	Unit
Power Supply Voltage	Vdd	25°C	3.1	3.3	3.5	V
Power Supply Current	Idd	Vdd=3.3V	--	0.5	1.0	mA
Input voltage (high)	Vih	Pins(SDA,SCL,RST)	1.9	--	Vdd	V
Input voltage (low)	Vil	Vdd=3.3V	-0.3	--	0.8	V
Recommended Driving Voltage	LC V0-Vss	-20°C	4.9	5.1	5.3	V
		25°C	4.6	4.8	5.0	
		80°C	4.2	4.4	4.6	

### 3.2 The Characteristics Of Backlight

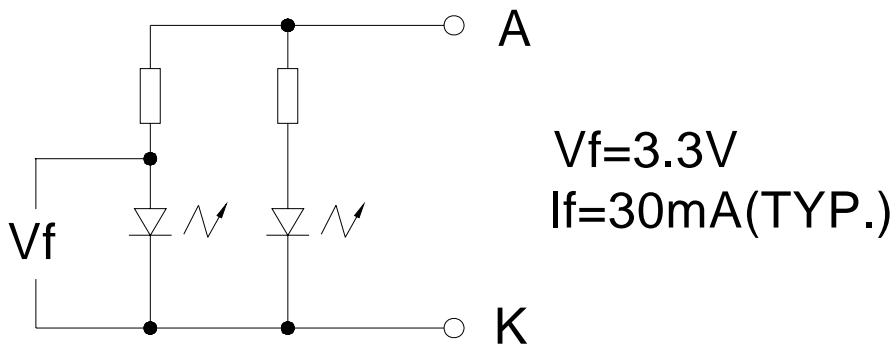
#### 3.2.1 Electrical-Optical Characteristics Of LED Backlight (Ta=25°C)

Item	Symbol	Condition	Min	Typ	Max	Unit
Forward Voltage <sup>(1)</sup>	Vf	If=30mA	2.9	3.1	3.3	V
Reverse Voltage	Vr	-	--	--	5	V
Luminance <sup>(2)</sup>	Lv	If=30mA	200	240	--	cd/m <sup>2</sup>
Uniformity <sup>(3)</sup>	Δ	(Lvmin/Lvmax)%	70%	--	--	-
Peak wave length	λ p	-	--	--	--	nm
Chroma coordinate	x	If=30mA	0.26	--	0.32	um
	y	If=30mA	0.26	--	0.32	um
Lifetime <sup>(4)</sup>	-	If=30mA	-	20000	-	Hours

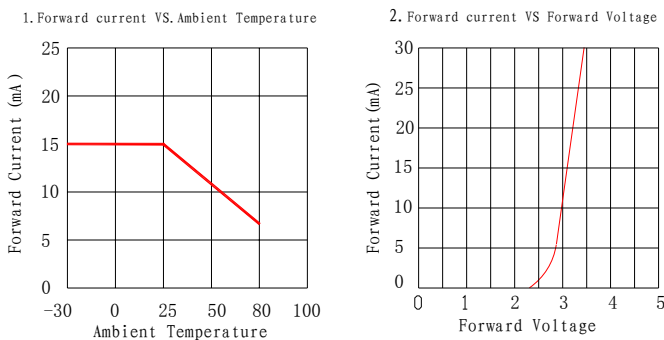
NOTE:

- (1) Forward voltage means voltage applied directly to the LED
- (2) The luminance is the average value of 5 points, The measurement instrument is BM-7 luminance colorimeter. The diameter of aperture is Φ5mm
- (3) Luminance means the backlight brightness without LCD.
- (4) Backlight lifetime means luminance value larger than half of the original after 20000 hours' continuous working.

#### 3.2.2 Backlight Control Circuit FOR LCM (1x2=2 pcs LED)



#### 3.2.3 LED Characteristics Curves (for single led)



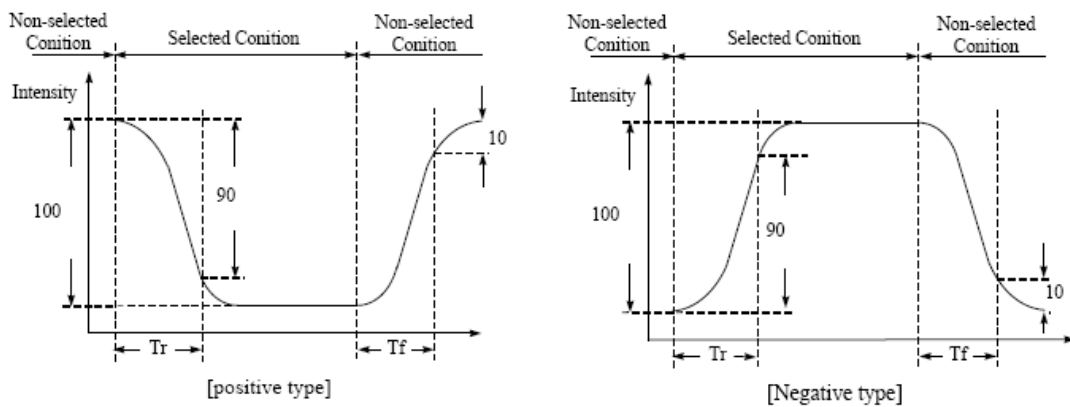
3.3 DC Characteristics

Symbol	Characteristics	Test Condition	Min.	Typ.	Max.	Unit
VDD	Operating Voltage	-	2.7	-	4.5	V
V <sub>LCD</sub>	LCD Voltage	V <sub>0</sub> -V <sub>ss</sub>	2.7	-	7.0	V
I <sub>CC</sub>	Power Supply Current	VDD=3.0V (Use internal booster/follower circuit)	-	160	230	uA
V <sub>IH1</sub>	Input High Voltage (Except OSC1)	-	1.9	-	VDD	V
V <sub>IL1</sub>	Input Low Voltage (Except OSC1)	-	- 0.3	-	0.8	V
V <sub>IH2</sub>	Input High Voltage (OSC1)	-	0.7 VDD	-	VDD	V
V <sub>IL2</sub>	Input Low Voltage (OSC1)	-	-	-	0.2 VDD	V
V <sub>OH1</sub>	Output High Voltage (DB0 - DB7)	I <sub>OH</sub> = -1.0mA	0.75 VDD	-	-	V
V <sub>OL1</sub>	Output Low Voltage (DB0 - DB7)	I <sub>OL</sub> = 1.0mA	-	-	0.8	V
V <sub>OH2</sub>	Output High Voltage (Except DB0 - DB7)	I <sub>OH</sub> = -0.04mA	0.8 VDD	-	VDD	V
V <sub>OL2</sub>	Output Low Voltage (Except DB0 - DB7)	I <sub>OL</sub> = 0.04mA	-	-	0.2 VDD	V
R <sub>COM</sub>	Common Resistance	V <sub>LCD</sub> = 4V, I <sub>d</sub> = 0.05mA	-	2	20	KΩ
R <sub>SEG</sub>	Segment Resistance	V <sub>LCD</sub> = 4V, I <sub>d</sub> = 0.05mA	-	2	30	KΩ
I <sub>LEAK</sub>	Input Leakage Current	V <sub>IN</sub> = 0V to VDD	-1	-	1	μA
I <sub>PUP</sub>	Pull Up MOS Current	VDD = 3V	20	30	40	μA
f <sub>OSC</sub>	Oscillation frequency	VDD = 3V, 1/17duty	350	540	1100	KHz

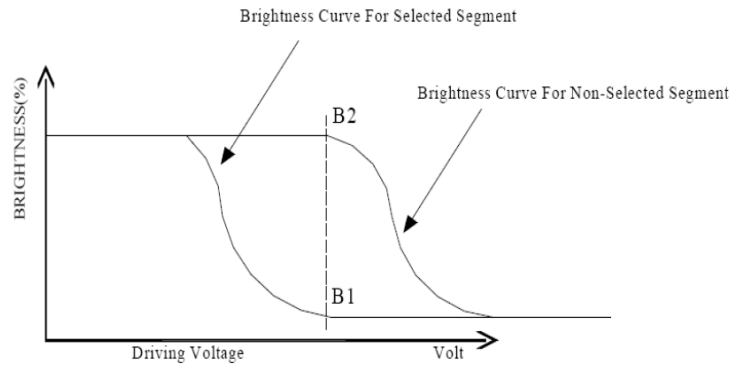
### 4.0 OPTICAL CHARACTERISTICS

Item	Symbol	Condition	Min	Typ	Max	Unit
Viewing angle (Left - right)	$\theta_2$	$Cr \geq 2.0$	-35	-	35	deg
Viewing angle (Up-down)	$\theta_1$	$Cr \geq 2.0$	-25	-	40	deg
Contrast Ratio	Cr	$\theta_1=0^\circ, \theta_2=0^\circ$	-	6	-	
Response time (rise)	Tr	$\theta_1=0^\circ, \theta_2=0^\circ$	-	180	300	ms
Response time (fall)	Tf	$\theta_1=0^\circ, \theta_2=0^\circ$	-	150	250	ms

#### (1). Definition of Optical Response Time

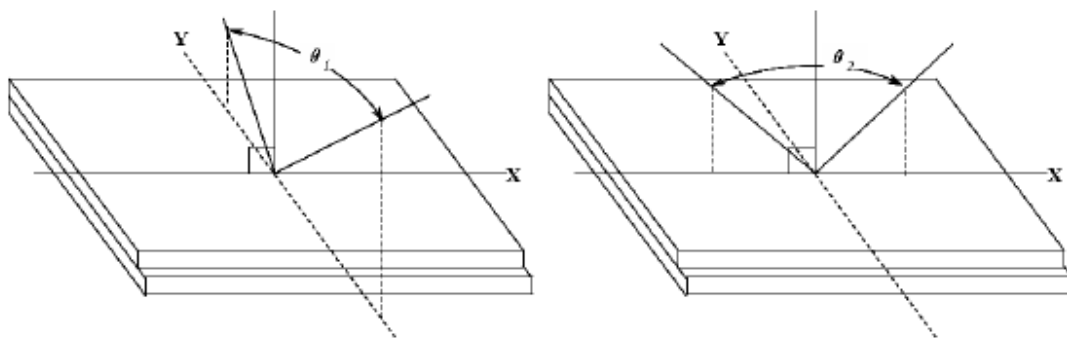


#### (2). Definition of Contrast Ratio

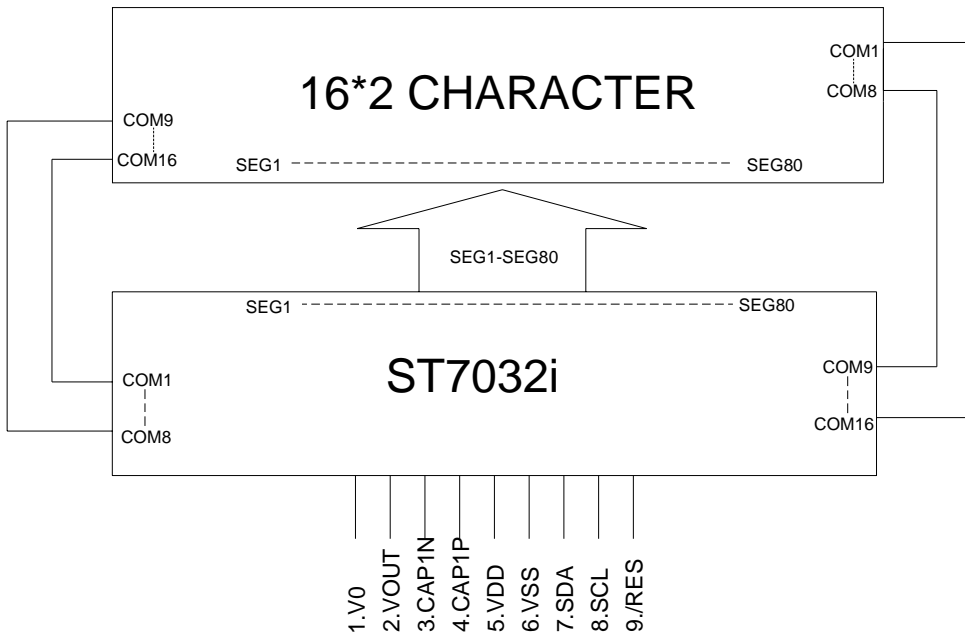


$$Cr = \frac{\text{Brightness of Non-selected Segment}(B2)}{\text{Brightness of selected Segment}(B1)}$$

#### (3). Definition of Viewing Angle $\theta_2$ and $\theta_1$



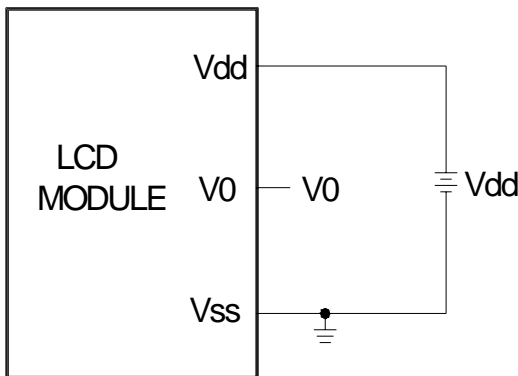
### 5.0 BLOCK DIAGRAM



### 6.0 PIN ASSIGNMENT

Pin No.	Symbol	Function
1	V0	Power supply for LCD drive
2	VOUT	Voltage converter input/output pin
3	CAP1N	Capacitor 1 negative connection pin for voltage converter
4	CAP1P	Capacitor 1 positive connection pin for voltage converter
5	VDD	Power Supply
6	VSS	Ground
7	SDA	Data input
8	SCL	Clock input
9	/RES	Reset signal

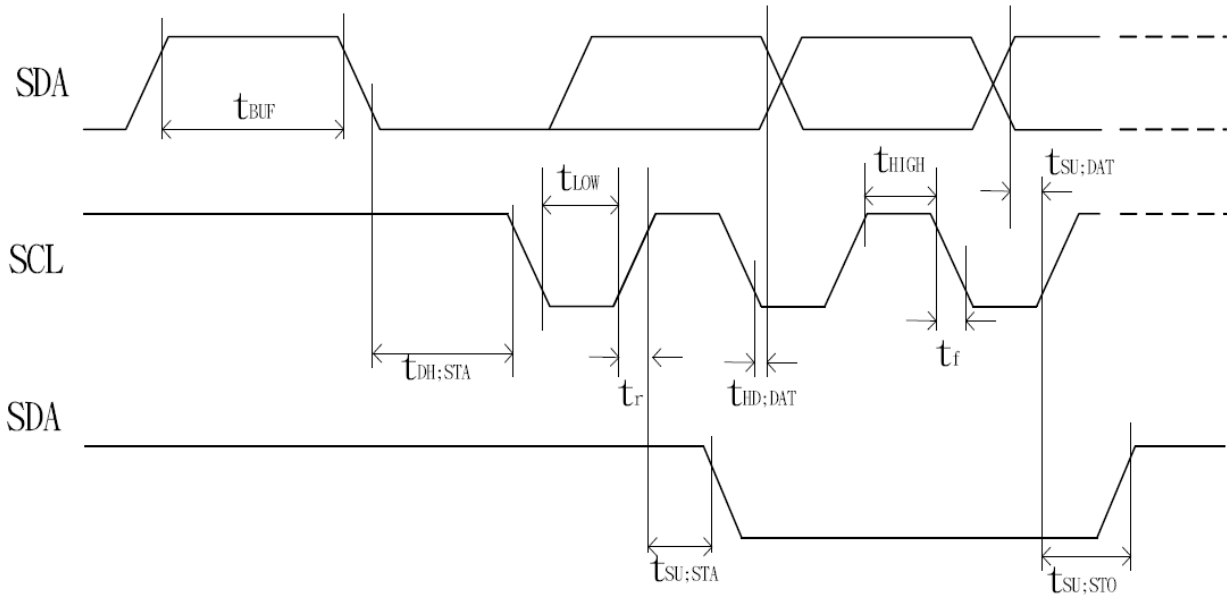
### 7.0 POWER SUPPLY





## 8.0 TIMING CHARACTERISTICS

- I2C interface

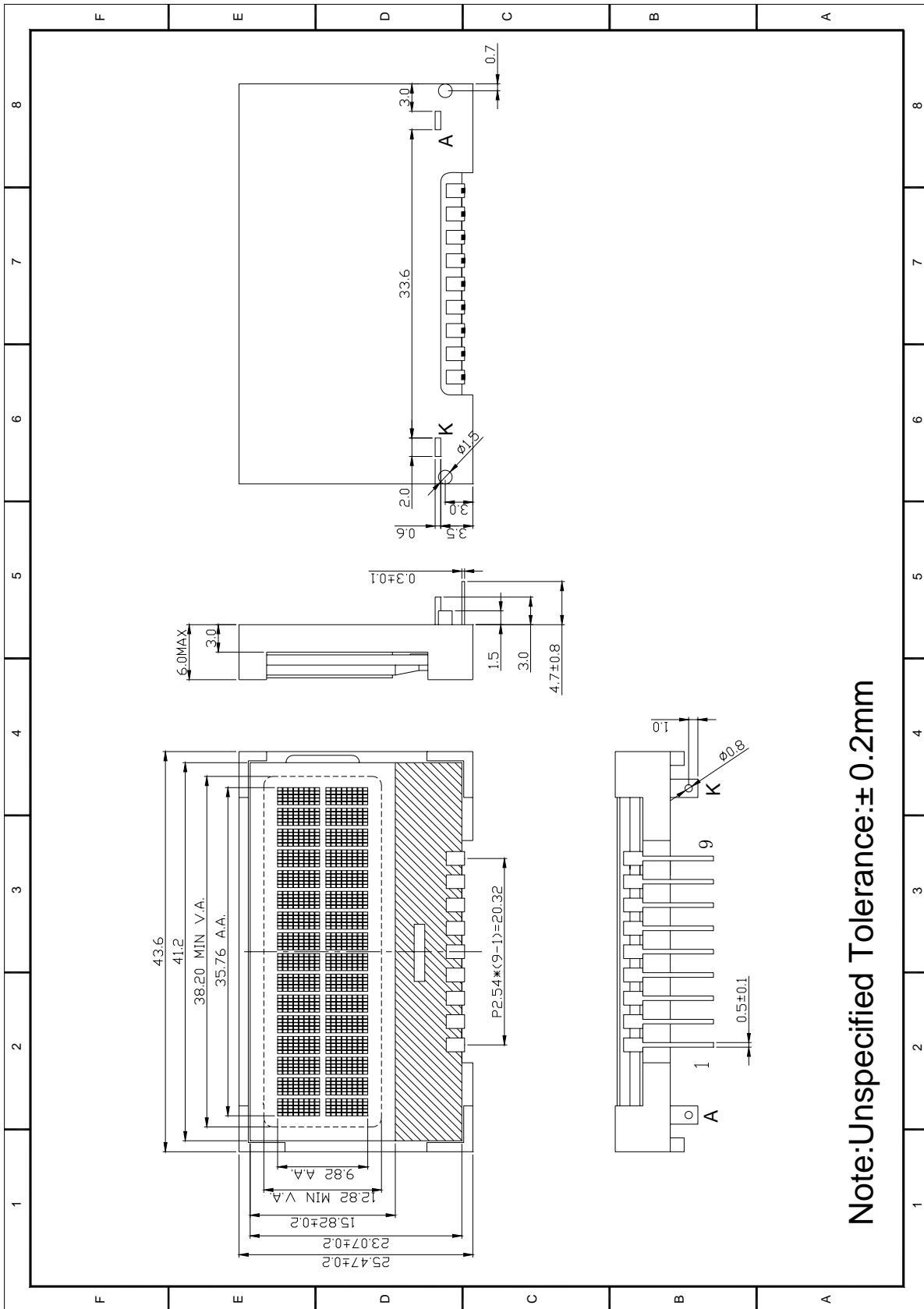


( Ta = -30°C to 85°C )

Item	Signal	Symbol	Condition	VDD=2.7 to 4.5V Rating		VDD=4.5 to 5.5V Rating		Units
				Min.	Max.	Min.	Max.	
SCL clock frequency	SCL	$f_{SCLK}$	—	DC	400	DC	400	KHz
SCL clock low period		$t_{LOW}$	—	1.3	—	1.3	—	us
SCL clock high period		$t_{HIGH}$	—	0.6	—	0.6	—	us
Data set-up time	SI	$t_{SU,DAT}$	—	<b>180</b>	—	100	—	ns
Data hold time		$t_{HD,DAT}$	—	0	0.9	0	0.9	us
SCL,SDA rise time	SCL, SDA	$t_r$	—	$20+0.1C_b$	300	$20+0.1C_b$	300	ns
SCL,SDA fall time		$t_f$	—	$20+0.1C_b$	300	$20+0.1C_b$	300	
Capacitive load represent by each bus line		$C_b$	—	—	400	—	400	pf
Setup time for a repeated START condition	SI	$t_{SU,STA}$	—	0.6	—	0.6	—	us
Start condition hold time		$t_{HD,STA}$	—	0.6	—	0.6	—	us
Setup time for STOP condition		$t_{SU,STO}$	—	0.6	—	0.6	—	us
Bus free time between a Stop and START condition	SCL	$t_{BUF}$	—	1.3	—	1.3	—	us

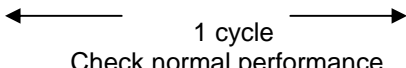
For more details, please refer to IC specification.

9.0 MECHANICAL DIAGRAM



Note: Unspecified Tolerance: ±0.2mm

**10.0 RELIABILITY TEST**

NO	Test Item	Description	Test Condition	Remark	
1	Environmental Test	High temperature storage	Applying the high storage temperature Under normal humidity for a long time Check normal performance	80 °C 96hrs	
2		Low temperature storage	Applying the low storage temperature Under normal humidity for a long time Check normal performance	-30°C 96hrs	
3		High temperature Operation	Apply the electric stress(Voltage and current) Under high temperature for a long time	70 °C 96hrs	Note1
4		Low temperature Operation	Apply the electric stress Under low temperature for a long time	-20°C 96hrs	Note1 Note2
5		High temperature/High Humidity Storage	Apply high temperature and high humidity storage for a long time	90% RH 40°C 96hrs	Note2
6		Temperature Cycle	Apply the low and high temperature cycle -30°C <> 25°C <> 80°C <> 25°C 30min 10min 30min 10min  1 cycle Check normal performance	-30°C/80°C 10 cycle	
7	Mechanical Test	Vibration test(Package state)	Applying vibration to product check normal performance	Freq:10~55~10Hz Amplitude:0.75mm 1cycle time:1min X.Y.Z every direction for 15 cycles	
8		Shock test(package state)	Applying shock to product check normal performance	Drop them through 70cm height to strike horizontal plane	
9	Other				

Remark

Note1:Normal operations condition (25°C±5°C).

Note2:Pay attention to keep dewdrops from the module during this test.

## 11.0 DISPLAY INSTRUCTION TABLE

➤ instruction table at “Extension mode”

(when “EXT” option pin connect to Vss, the instruction set follow below table)

Instruction	Instruction Code										Description	Instruction Execution Time		
	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		OSC=380KHz	OSC=540kHz	OSC=700KHz
Clear Display	0	0	0	0	0	0	0	0	0	1	Write "20H" to DDRAM. and set DDRAM address to "00H" from AC	1.08 ms	0.76 ms	0.59 ms
Return Home	0	0	0	0	0	0	0	0	1	x	Set DDRAM address to "00H" from AC and return cursor to its original position if shifted. The contents of DDRAM are not changed.	1.08 ms	0.76 ms	0.59 ms
Entry Mode Set	0	0	0	0	0	0	0	1	I/D	S	Sets cursor move direction and specifies display shift. These operations are performed during data write and read.	26.3 us	18.5 us	14.3 us
Display ON/OFF	0	0	0	0	0	0	1	D	C	B	D=1:entire display on C=1:cursor on B=1:cursor position on	26.3 us	18.5 us	14.3 us
Function Set	0	0	0	0	1	DL	N	DH	*0	IS	DL: interface data is 8/4 bits N: number of line is 2/1 DH: double height font IS: instruction table select	26.3 us	18.5 us	14.3 us
Set DDRAM address	0	0	1	AC6	AC5	AC4	AC3	AC2	AC1	AC0	Set DDRAM address in address counter	26.3 us	18.5 us	14.3 us
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	0	0
Write data to RAM	1	0	D7	D6	D5	D4	D3	D2	D1	D0	Write data into internal RAM (DDRAM/CGRAM/ICONRAM)	26.3 us	18.5 us	14.3 us
Read data from RAM	1	1	D7	D6	D5	D4	D3	D2	D1	D0	Read data from internal RAM (DDRAM/CGRAM/ICONRAM)	26.3 us	18.5 us	14.3 us

Note \*: this bit is for test command , and must always set to "0"

### Instruction table 0(IS=0)

Cursor or Display Shift	0	0	0	0	0	1	S/C	R/L	x	x	S/C and R/L: Set cursor moving and display shift control bit, and the direction, without changing DDRAM data.	26.3 us	18.5 us	14.3 us
Set CGRAM	0	0	0	1	AC5	AC4	AC3	AC2	AC1	AC0	Set CGRAM address in address counter	26.3 us	18.5 us	14.3 us

### Instruction table 1(IS=1)

Internal OSC frequency	0	0	0	0	0	1	BS	F2	F1	F0	BS=1:1/4 bias BS=0:1/5 bias F2~0: adjust internal OSC frequency for FR frequency.	26.3 us	18.5 us	14.3 us
Set ICON address	0	0	0	1	0	0	AC3	AC2	AC1	AC0	Set ICON address in address counter.	26.3 us	18.5 us	14.3 us
Power/ICON control/Contrast set	0	0	0	1	0	1	Ion	Bon	C5	C4	Ion: ICON display on/off Bon: set booster circuit on/off C5,C4: Contrast set for internal follower mode.	26.3 us	18.5 us	14.3 us
Follower control	0	0	0	1	1	0	Fon	Rab2	Rab1	Rab0	Fon: set follower circuit on/off Rab2~0: select follower amplified ratio.	26.3 us	18.5 us	14.3 us
Contrast set	0	0	0	1	1	1	C3	C2	C1	C0	Contrast set for internal follower mode.	26.3 us	18.5 us	14.3 us

## 12.0 STANDARD CHARACTER PATTERNS

ST7032-0D (ITO option OPR1=1, OPR2=1)

b7-b4 b3-b0	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
0000	0	1	2	3	4	5	6	7	8	9	.	,	-	=	+	*
0001	J	T	L	1	R	0	a	9	0	a	.	7	*	4	1	1
0010	o	s	"	2	B	R	b	r	e	E	T	Y	U	X	6	*
0011	P	n	N	3	C	S	c	s	A	a	U	o	T	E	0	*
0100	d	n	*	4	D	T	d	t	a	a	.	I	T	R	0	*
0101	↑	Δ	Σ	5	E	U	e	u	Δ	Δ	.	7	*	1	E	1
0110	↓	θ	⊗	6	F	U	f	u	Δ	Δ	7	o	2	3	*	U
0111	→	△	↑	7	G	U	g	u	Δ	Δ	7	7	*	7	R	⊗
1000	←	∇	∇	8	H	X	h	x	Δ	Δ	4	o	*	U	*	+
1001	□	Π	∇	9	I	Y	i	y	Δ	Δ	o	7	U	U	1	Σ
1010	▯	Σ	*	*	J	Z	j	z	Δ	Δ	e	o	n	U	Δ	Σ
1011	L	ρ	+	*	K	L	k	l	Δ	Δ	*	o	E	o	Δ	⊗
1100	U	⊗	.	<	L	*	l	l	Δ	Δ	*	o	o	o	Δ	⊗
1101	.	μ	-	=	M	I	m	i	Δ	Δ	u	*	Δ	U	Δ	*
1110	0	0	.	>	N	^	n	^	Δ	Δ	o	E	o	Δ	o	J
1111	0	o	/	?	o	l	o	e	Δ	Δ	u	U	7	μ	o	▯

Note: The character generator RAM is the RAM with which the user can rewrite character patterns by program.

### 13.0 RECOMMENDED INITIAL CODE

```
void ST7032I_1602_inilcd(void)
{
    ST7032I_1602_writecommand(0x38);// Function Set, 2 line mode normal display
    ST7032I_1602_writecommand(0x39);// Unction Set, extension instruction be selected
    ST7032I_1602_writecommand(0x14);// BS=0:1/5 BIAS;F2 F1 F0:100(internal osc)
    ST7032I_1602_writecommand(0x73);// Contrast set
    ST7032I_1602_writecommand(0x5E);// Icon on,booster circuit on
    ST7032I_1602_writecommand(0x6C);// Follower circuit on
    ST7032I_1602_writecommand(0x0C);// Entire display on
    ST7032I_1602_writecommand(0x01);// Clear display
    ST7032I_1602_writecommand(0x06);// Entry Mode Set ,increment
}
```

## 14.0 PRECAUTION FOR USING LCM

1. When design the product with this LCD Module, make sure the viewing angle matches to its purpose of usage.
2. As LCD panel is made of glass substrate, Dropping the LCD module or banging it against hard objects may cause cracking or fragmentation. Especially at corners and edges.
3. Although the polarizer of this LCD Module has the anti-glare coating, always be careful not to scratch its surface. Use of a plastic cover is recommended to protect the surface of polarizer.
4. If the LCD module is stored at below specified temperature, the LC material may freeze and be deteriorated. If it is stored at above specified temperature, the molecular orientation of the LC material may change to Liquid state and it may not revert to its original state. Excessive temperature and humidity could cause polarizer peel off or bubble. Therefore, the LCD module should always be stored within specified temperature range.
5. Saliva or water droplets must be wiped off immediately as those may leave stains or cause color changes if remained for a long time. Water vapor will cause corrosion of ITO electrodes.
6. If the surface of LCD panel needs to be cleaned, wipe it swiftly with cotton or other soft cloth. If it is not still clean enough, blow a breath on the surface and wipe again.
7. The module should be driven according to the specified ratings to avoid malfunction and permanent damage.  
Applying DC voltage cause a rapid deterioration of LC material. Make sure to apply alternating waveform by continuous application of the M signal. Especially the power ON/OFF sequence should be kept to avoid latchup of driver LSIs and DC charge up to LCD panel.

### 8. Mechanical Considerations

- a) LCM are assembled and adjusted with a high degree of precision. Avoid excessive shocks and do not make any alterations or modifications. The following should be noted.
- b) Do not tamper in any way with the tabs on the metal frame.
- c) Do not modify the PCB by drilling extra holes, changing its outline, moving its components or modifying its pattern.
- d) Do not touch the elastomer connector; especially insert a backlight panel (for example, EL).
- e) When mounting a LCM makes sure that the PCB is not under any stress such as bending or twisting.  
Elastomer contacts are very delicate and missing pixels could result from slight dislocation of any of the elements.
- f) Avoid pressing on the metal bezel, otherwise the elastomer connector could be deformed and lose contact, resulting in missing pixels.

### 9. Static Electricity

#### a) Operator

**Ware the electrostatics shielded clothes because human body may be statically charged if not ware shielded clothes. Never touch any of the conductive parts such as the LSI pads; the copper leads on the PCB and the interface terminals with any parts of the human body.**

#### b) Equipment

There is a possibility that the static electricity is charged to the equipment, which has a function of peeling or friction action (ex: conveyer, soldering iron, working table). Earth the equipment through proper resistance (electrostatic earth:  $1 \times 10^8$  ohm).

Only properly grounded soldering irons should be used.

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If an electric screwdriver is used, it should be well grounded and shielded from commutator sparks.

The normal static prevention measures should be observed for work clothes and working benches; for the latter conductive (rubber) mat is recommended.

### c) Floor

**Floor is the important part to drain static electricity, which is generated by operators or equipment.**

There is a possibility that charged static electricity is not properly drained in case of insulating floor. Set the electrostatic earth (electrostatic earth:  $1 \times 10^8$  ohm).

### d) Humidity

Proper humidity helps in reducing the chance of generating electrostatic charges. Humidity should be kept over 50%RH.

### e) Transportation/storage

**The storage materials also need to be anti-static treated because there is a possibility that the human body or storage materials such as containers may be statically charged by friction or peeling.**

The modules should be kept in antistatic bags or other containers resistant to static for storage.

### f) Soldering

Solder only to the I/O terminals. Use only soldering irons with proper grounding and no leakage.

Soldering temperature :  $280^{\circ} \text{C} \pm 10^{\circ} \text{C}$

Soldering time: 3 to 4 sec.

Use eutectic solder with resin flux fill.

If flux is used, the LCD surface should be covered to avoid flux spatters. Flux residue should be removed afterwards.

### g) Others

**The laminator (protective film) is attached on the surface of LCD panel to prevent it from scratches or stains. It should be peeled off slowly using static eliminator.**

Static eliminator should also be installed to the workbench to prevent LCD module from static charge.

### 10. Operation

a) Driving voltage should be kept within specified range; excess voltage shortens display life.

b) Response time increases with decrease in temperature.

c) Display may turn black or dark blue at temperatures above its operational range; this is (however not pressing on the viewing area) may cause the segments to appear "fractured".

d) Mechanical disturbance during operation (such as pressing on the viewing area) may cause the segments to appear "fractured".

11. If any fluid leaks out of a damaged glass cell, wash off any human part that comes into contact with soap and water. The toxicity is extremely low but caution should be exercised at all the time.

12. Disassembling the LCD module can cause permanent damage and it should be strictly avoided.

13. LCD retains the display pattern when it is applied for long time (Image retention). To prevent image retention, do not apply the fixed pattern for a long time. Image retention is not a deterioration of LCD. It will be removed after display pattern is changed.

14. Do not use any materials, which emit gas from epoxy resin (hardener for amine) and silicone adhesive agent (dealcohol or deoxym) to prevent discoloration of polarizer due to gas.



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15. Avoid the exposure of the module to the direct sunlight or strong ultraviolet light for a long time.
16. The brightness of LCD module may be affected by the routing of CCFL cables due to leakage to the chassis through coupling effect. The inverter circuit needs to be designed taking the level of leakage current into consideration. Thorough evaluation is needed for LCD module and inverter built into its host equipment to ensure specified brightness.