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*Electronic Products for the OEM*

# LCD PRODUCT SPECIFICATION

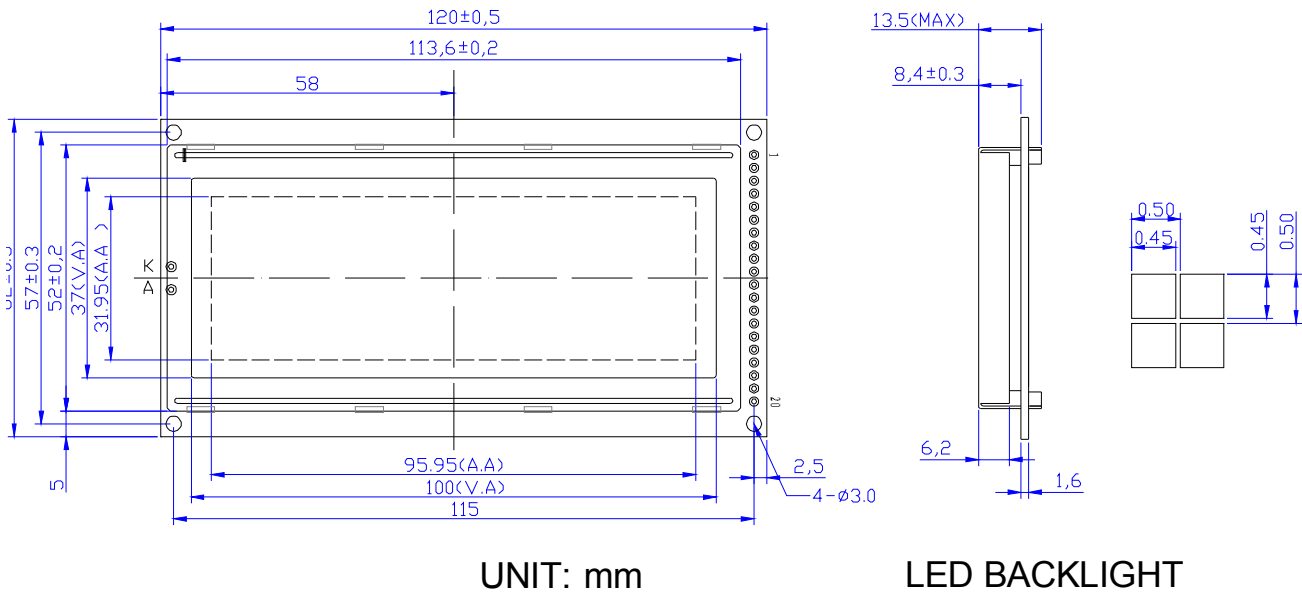
<b>PART NUMBER:</b>	<b>USMPG-TQ16032C-SZWBI-P4</b>
<b>DESCRIPTION:</b>	160x32 Graphic LCD; STN Blue Display Mode; Transflective, Positive with White LED Sidelight and 6 O'Clock Viewing Direction.

ISSUE DATE	APPROVED BY (Customer Use Only)	CHECKED BY	PREPARED BY
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## Features

- a) 192x64 dots graphic LCD module
- b) Low power consumption
- c) Built-in controller (NT7108C)
- d) +5V power supply
- e) 1/64 duty cycle
- f) Easy interface with 8-bit MPU
- g) LED backlight optional
- h) Negative voltage optional

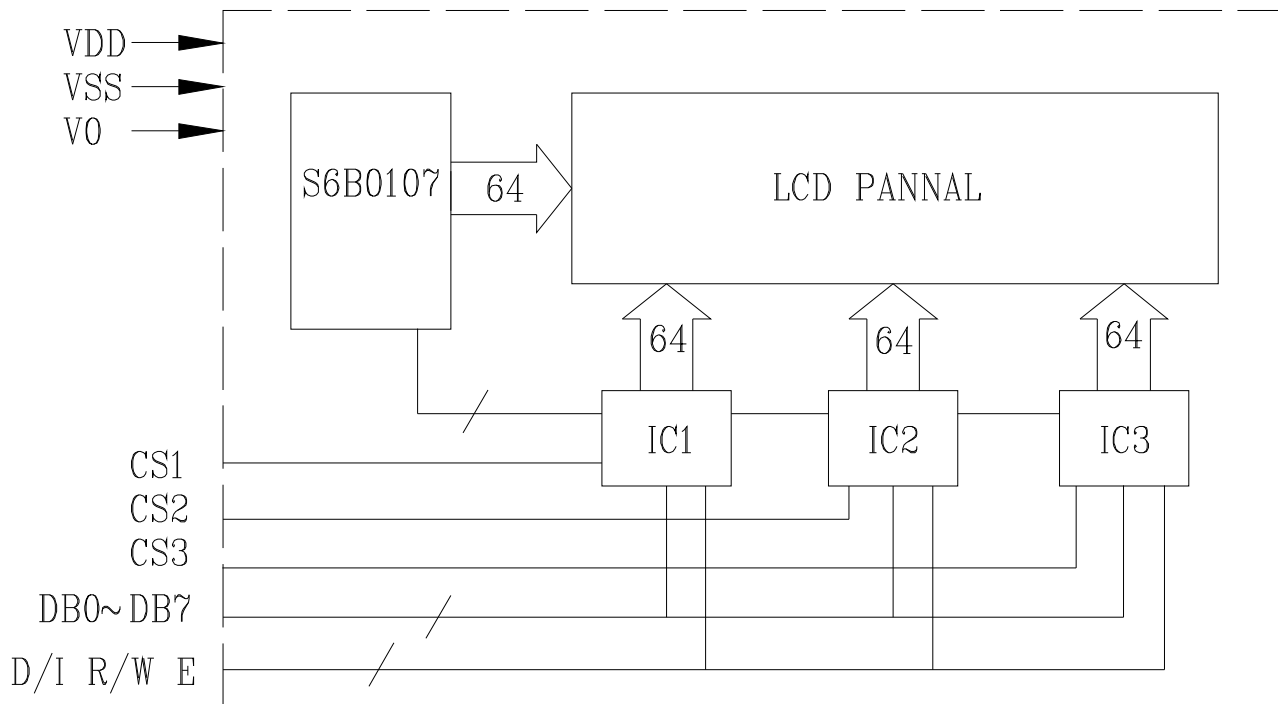
## Mechanical Specifications



## Absolute maximum ratings

Item	Symbol	Min.	Max.	Unit
Supply voltage for logic	Vdd - Vss	0	6.5	V
Input voltage	Vin	0	Vdd	
Operating temperature range	Top	-20	70	°C
Storage temperature range	Tst	-30	80	

**BLOCK DIAGRAM**

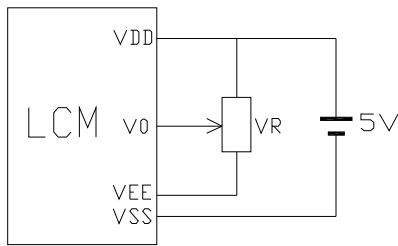


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**Interface Pin Connections**

Pin No.	Symbol	Level	Description
1	VSS	0V	Ground
2	VDD	5.0V	Supply voltage for logic and LCD (+)
3	V0	-	Operating voltage for LCD (variable)
4	VEE	OUT	VEE is connected by the same voltage.
5	D/I	H/L	H: data, L: instruction code
6	R/W	H/L	H: read (MUP←module),L: write (MPU→module)
7	E	H, H→L	Chip enable signal
8~15	DB0~DB7	H/L	Data bit 0~7
16	CS1	H	Chip select A
17	CS2	H	Chip select B
18	CS3	H	Chip select C
19	RST	L	Reset signal. When RSTB=L
20	LED+	5.0V	Backlight power supply

**CONTRAST ADJUST**



V<sub>DD</sub>-V<sub>0</sub>: LCD Driving voltage

VR: 10k~20k

**Optical characteristics**

STN Type display module (Ta=25°C, V<sub>dd</sub>=5.0V)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Viewing angle	θ	Cr ≥ 2	-60	-	35	deg
	φ		-40	-	40	
Contrast ratio (rise)	Cr	-	-	8	-	
Response time (fall)	Tr	-	-	200	250	ms
	Tr	-	-	300	350	ms

**Electrical characteristics**

Item	Symbol	Condition	Standard value			Unit	
			Min.	Typ.	Max.		
Supply voltage for	Logic	V <sub>dd</sub> - V <sub>ss</sub>	-	4.75	5.0	5.25	V
	LCD	V <sub>dd</sub> -V <sub>0</sub>	-	-	13.8	-	
Supply current for	Logic	I <sub>dd</sub>	-	-	13.5	-	mA
	LCD	I <sub>ee</sub>	-	-	1.0	-	
Operating voltage for LCD (Recommended)		V <sub>dd</sub> -v <sub>0</sub>	-	-	-	-	V
			25°C	-	13.8	-	
			-	-	-	-	
Input voltage	H: level	V <sub>ih</sub>	High level	0.7V <sub>dd</sub>	-	V <sub>dd</sub>	V
	L: Level	V <sub>il</sub>	Low level	0	-	0.3V <sub>dd</sub>	

**Electrical Absolute Maximum Ratings**

Parameter	Symbol	Rating	Unit	Note
Operating voltage	V <sub>DD</sub>	-0.3 ~ +7.0	V	*1
Supply voltage	V <sub>EE</sub>	V <sub>DD</sub> -19.0 ~ V <sub>DD</sub> +0.3	V	*4
Driver supply voltage	V <sub>B</sub>	-0.3 ~ V <sub>DD</sub> +0.3	V	*1,2
	V <sub>LCD</sub>	V <sub>EE</sub> -0.3 ~ V <sub>DD</sub> +0.3	V	*3,4

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**\*Notes:**

- \*1. Based on  $V_{SS} = 0V$
- \*2. Applies to input terminals and I/O terminals at high impedance. (Except V0L, V1L, V4L, and V5L)
- \*3. Applies to V0L, V1L, V4L, and V5L.
- \*4. Voltage level:  $V_{DD} \geq V0 \geq V1 \geq V2 \geq V3 \geq V4 \geq V5 \geq V_{EE}$

**DC Electrical Characteristics**

 (VDD= 4.5 to 5.5V, VSS=0V, VDD-V<sub>EE</sub>=8~17V, T<sub>a</sub>= -30 to +85°C)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Note
Operating voltage	V <sub>DD</sub>	-	4.5	-	5.5	V	
Input voltage	V <sub>IH</sub>	-	0.7V <sub>DD</sub>	-	V <sub>DD</sub>		*1
	V <sub>IL</sub>	-	V <sub>SS</sub>	-	0.3V <sub>DD</sub>		
output voltage	V <sub>OH</sub>	I <sub>OH</sub> = -0.4mA	V <sub>DD</sub> -0.4	-	-		*2
	V <sub>OL</sub>	I <sub>OL</sub> = 0.4mA	-	-	0.4		
Input leakage current	I <sub>LKG</sub>	V <sub>IN</sub> = V <sub>DD</sub> ~ V <sub>SS</sub>	-1.0	-	+1.0	μA	*1
OSC Frequency	f <sub>osc</sub>	R <sub>f</sub> =47kΩ ±2% C <sub>f</sub> =20pF ±5%	315	450	585	kHz	
On Resistance (V <sub>div</sub> -C <sub>i</sub> )	R <sub>ONS</sub>	V <sub>DD</sub> -V <sub>EE</sub> =17V Load current ±150μA	-	-	1.5	kΩ	
Operating current	I <sub>DD1</sub>	Master mode 1/128 Duty	-	-	1.0	mA	*3
	I <sub>DD2</sub>	Master mode 1/128 Duty	-	-	0.2		*4
Supply Current	I <sub>EE</sub>	Master mode 1/128 Duty	-	-	0.1		
Operating Frequency	f <sub>op1</sub>	Master mode External Duty	50	-	600	kHz	
Frequency	f <sub>op2</sub>	Slave mode	0.5	-	1500		

**Notes**

- \*1. Applies to input terminals FS, DS1, DS2, CR, SHL, MS and PCLK2 and I/O terminals DIO1, DIO2, M, and CL2 in the input state.
- \*2. Applies to output terminals CLK1, CLK2 and FRM and I/O terminals DIO1, DIO2, M, and CL2 in the output state.
- \*3. This value is specified about current flowing through V<sub>ss</sub>  
Internal oscillation circuit: R<sub>f</sub>=47kΩ, c<sub>f</sub>=20pF  
Each terminals of DS1, DS2, FS, SHL, and MS is connected to V<sub>DD</sub> and out is no load.
- \*4. This value is specified about current flowing through V<sub>ss</sub>  
Each terminals is DS1, DS2, FS, SHL, PCLK2 and CR is connected to V<sub>DD</sub>, MS is connected to V<sub>ss</sub> and CL2, M, DIO1 is external clock.
- \*5. This value is specified about current flowing through V<sub>EE</sub>. Don't connect to V<sub>LCD</sub> (V1~V5).

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## Electrical Absolute Maximum Ratings (NT7108C)

Parameter	Symbol	Rating	Unit	Note
Operating voltage	V <sub>DD</sub>	-0.3 ~ +7.0	V	*1
Supply voltage	V <sub>EE</sub>	V <sub>DD</sub> -19.0 ~ V <sub>DD</sub> +0.3	V	*4
Driver supply voltage	V <sub>B</sub>	-0.3 ~ V <sub>DD</sub> +0.3	V	*1,3
	V <sub>LCD</sub>	V <sub>0</sub> -0.3 ~ V <sub>DD</sub> +0.3	V	*2

### \*Notes:

- \*1. Based on V<sub>SS</sub> = 0V
- \*2. Applies the same supply voltage to V<sub>EE</sub>. V<sub>LCD</sub>=V<sub>DD</sub>-V<sub>EE</sub>
- \*3. Applies to M, FRM, CLK1, CLK2, CL, RESETB, ADC, CS1B, CS2B, CS3, E, R/W, RS and DB0~DB7.
- \*4. Applies V0L, V2L, V3L and V5L.

Voltage level: V<sub>DD</sub> ≥ V0 ≥ V1 ≥ V2 ≥ V3 ≥ V4 ≥ V5 ≥ V<sub>EE</sub>

## DC Electrical Characteristics (NT7108C)

(V<sub>DD</sub>= 4.5 to 5.5V, V<sub>SS</sub>=0V, V<sub>DD</sub>-V<sub>EE</sub>=8~17V, T<sub>a</sub>= -30 to +85°C)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Note
Operating voltage	V <sub>DD</sub>	-	4.5	-	5.5	V	
Input High voltage	V <sub>IH1</sub>	-	0.7V <sub>DD</sub>	-	V <sub>DD</sub>		*1
	V <sub>IH2</sub>	-	2.0	-	V <sub>DD</sub>		*2
Input Low voltage	V <sub>IL1</sub>	-	0	-	0.3V <sub>DD</sub>		*1
	V <sub>IL2</sub>	-	0	-	0.8		*2
Output High Voltage	V <sub>OH</sub>	I <sub>OH</sub> = -0.2mA	2.4	-	-		*3
Output Low Voltage	V <sub>OL</sub>	I <sub>OL</sub> = 1.6mA	-	-	0.4	*3	
Input leakage current	I <sub>LKG</sub>	V <sub>IN</sub> = V <sub>SS</sub> ~ V <sub>DD</sub>	-1.0	-	+1.0	μA	*4
Three-state (OFF) Input Current	I <sub>TSL</sub>	V <sub>IN</sub> = V <sub>SS</sub> ~ V <sub>DD</sub>	-5.0	-	5.0		*5
Driver Input leakage current	I <sub>DIL</sub>	V <sub>IN</sub> = V <sub>EE</sub> ~ V <sub>DD</sub>	-2.0		2.0		*6
On Resistance (V <sub>div</sub> -C <sub>i</sub> )	R <sub>ONS</sub>	V <sub>DD</sub> -V <sub>EE</sub> =15V Load current ±100μA	-	-	7.5	kΩ	*8
Operating current	I <sub>DD1</sub>	During Display	-	-	0.1	mA	*7
	I <sub>DD2</sub>	During Access Access Cycle=1MHz	-	-	0.5		*7

### Notes

- \*1. CL, FRM, M, RSTB, CLK1, CLK2
- \*2. CS1B, CS2B, CS3, E, R/W, RS, DB0~DB7
- \*3. DB0~DB7
- \*4. Except DB0~DB7
- \*5. DB0~DB7 at high impedance
- \*6. V0, V1, V3, V3, V4, V5
- \*7. 1/64 duty, FCLK=250KHZ, Frame Frequency=70HKZ, Output: No Load

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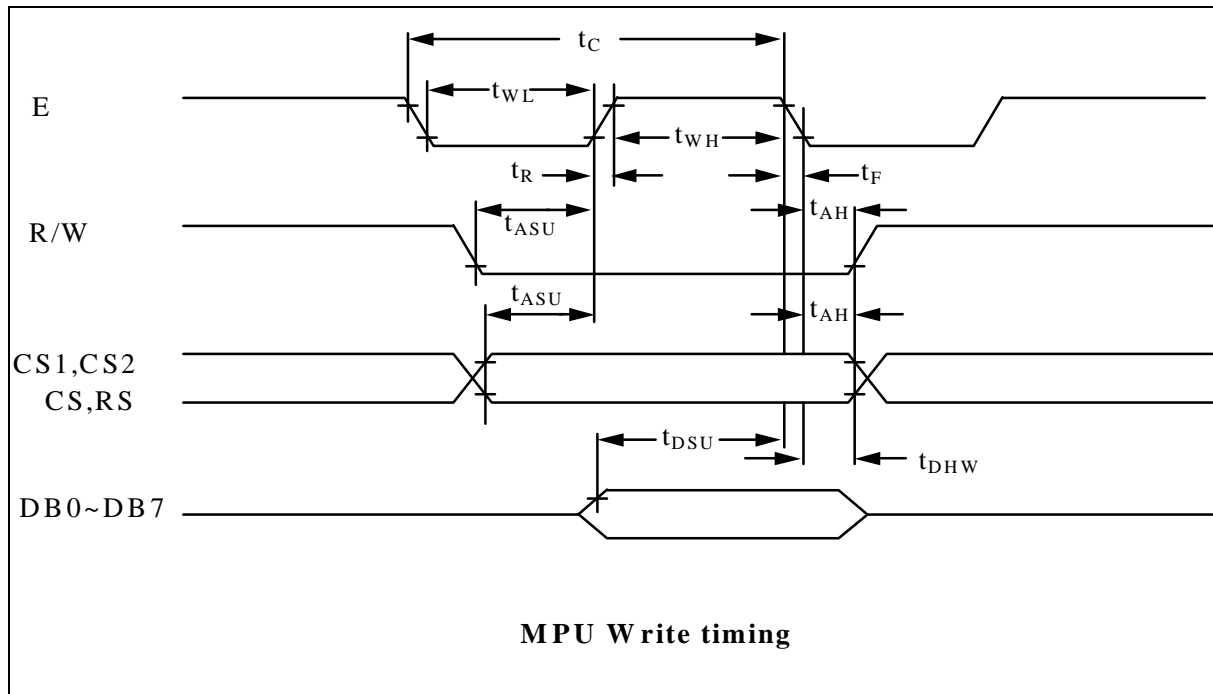
\*8.  $V_{DD}-V_0=13.8V$

$V_{OL}>V_{2L}>= V_{DD}-2/7(V_{DD}-V_{EE})>V_{3L}= V_{EE}+2/7(V_{DD}-V_{EE})>V_{5L}$

## Write or read cycle

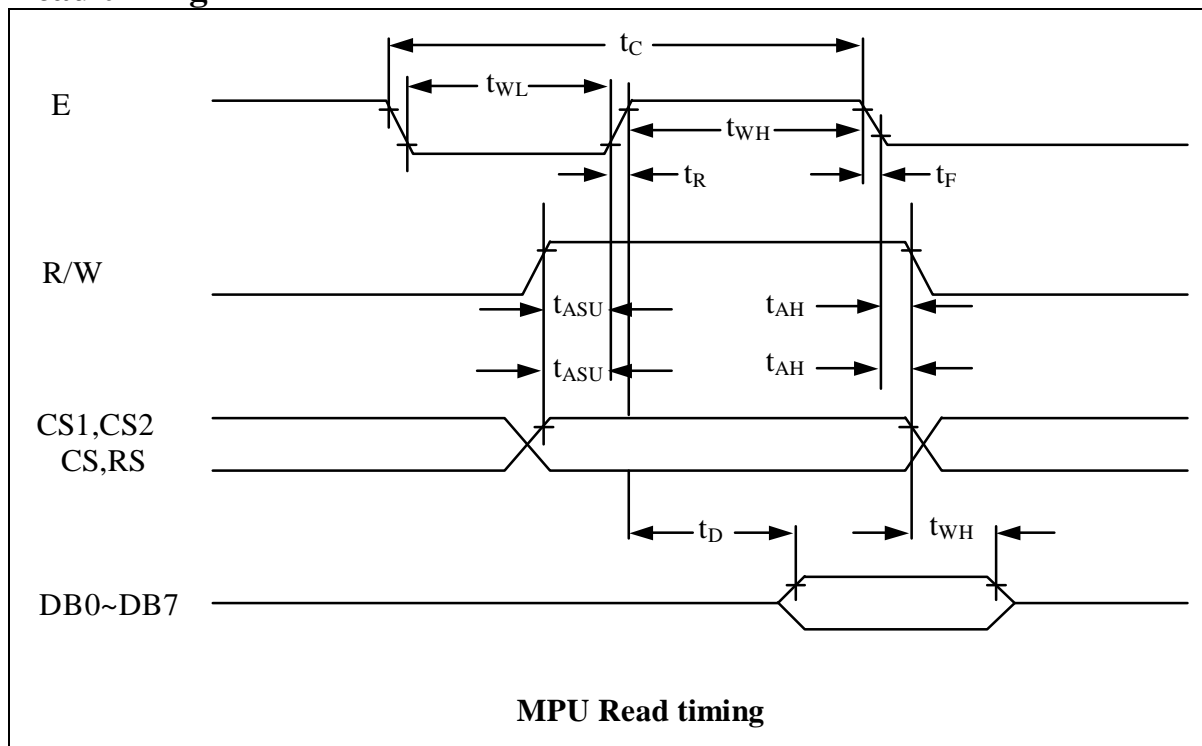
Characteristic	Symbol	Min.	Typ.	Max.	Unit
E cycle	Tc	1000	-	-	ns
E high level width	Twh	450	-	-	ns
E low level width	Twl	450	-	-	ns
E rise time	Tr	-	-	25	ns
E fall time	Tf	-	-	25	ns
Address set-up time	Tasu	140	-	-	ns
Address hold time	Tah	10	-	-	ns
Data set-up time	Tdsu	200	-	-	ns
Data delay time	Td	-	-	320	ns
Data hold time (write)	Tdhw	10	-	-	ns
Data hold time (read)	Tdhr	20	-	-	ns

## Write timing



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**Read timing**



**Display Control Instruction**

The display control instructions control the internal state of the NT7108C. Instruction is received from MPU to NT7108C for the display control. The following table shows various instructions.

Instruction	RS	RW	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Function
Read Display Data	1	1	Read data								Reads data (DB[7:0]) from display data RAM to the data bus.
Write Display Data	1	0	Write data								Writes data (DB[7:0]) into display data RAM. After writing instruction, Y address is incremented by 1 automatically
Status Read	0	1	Busy	0	ON/OFF	Re-set	0	0	0	0	Reads the internal status BUSY 0: Ready 1: In operation ON/OFF 0: Display ON 1: Display OFF RESET

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											0: Normal 1: Reset
Set Address (Y address)	0	0	0	1	Y address (0~63)						Sets the Y address in the Y address counter
Set Display Start Line	0	0	1	1	Display start line (0~63)						Indicates the display data RAM displayed at the top of the screen.
Set Address (X address)	0	0	1	0	1	1	1	Page (0~7)			Sets the X address at the X address register.
Display On/off	0	0	0	0	1	1	1	1	1	0/1	Controls the display ON or OFF. The internal status and the DDRAM data is not affected. 0: OFF, 1: ON

### 1. Display On/Off

The display data appears when D is 1 and disappears when D is 0.

Though the data is not on the screen with D=0, it remains in the display data RAM.

Therefore, you can make it appear by changing D=0 into D=1.

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	1	1	1	1	1	D

### 2. Set Address (Y Address)

Y address (AC0~AC5) of the display data RAM is set in the Y address counter.

An address is set by instruction and increased by 1 automatically by read or write operations of display data.

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	1	AC5	AC4	AC3	AC2	AC1	AC0

### 3. Set Page (X Address)

X address (AC0~AC2) of the display data RAM is set in the X address register.

Writing or reading to or from MPU is executed in this specified page until the next page is set.

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	1	0	1	1	1	AC2	AC1	AC0

### 4. Display Start Line (Z Address)

Z address (AC0~AC5) of the display data RAM is set in the display start line register and displayed at the top of the screen.

When the display duty cycle is 1/64 or others (1/32~1/64), the data of total line number of LCD screen, from the

line specified by display start line instruction, is displayed.

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	1	1	AC5	AC4	AC3	AC2	AC1	AC0

## 5. Status Read

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
1	0	BUSY	0	ON/OFF	RESET	0	0	0	0

### I BUSY

When BUSY is 1, the Chip is executing internal operation and no instructions are accepted.

When BUSY is 0, the Chip is ready to accept any instructions.

### I ON/OFF

When ON/OFF is 1, the display is on.

When ON/OFF is 0, the display is off.

### I RESET

When RESET is 1, the system is being initialized.

In this condition, no instructions except status read can be accepted.

When RESET is 0, initializing has finished and the system is in the usual operation condition.

## 6. Write Display Data

Writes data (D0~D7) into the display data RAM.

After writing instruction, Y address is increased by 1 automatically.

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
1	0	D7	D6	D5	D4	D3	D2	D1	D0

## 7. Read Display Data

Reads data (D0~D7) from the display data RAM.

After reading instruction, Y address is increased by 1 automatically.

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
1	1	D7	D6	D5	D4	D3	D2	D1	D0

## Operating principles & methods

### 1. I/O Buffer

Input buffer controls the status between the enable and disable of chip. Unless the CS1B to CS3 is in active mode, Input or output of data and instruction does not execute. Therefore internal state is not change. But RSTB and ADC can operate regardless CS!B-CS3.

### 2. Input register

Input register is provided to interface with MPU which is different operating frequency. Input register stores the

data temporarily before writing it into display RAM.

When CS1B to CS3 are in the active mode, R/W and RS select the input register. The data from MPU is written into input register. Then writing it into display RAM. Data latched for falling of the E signal and write automatically into the display data RAM by internal operation.

**3. Output register**

Output register stores the data temporarily from display data RAM when CS1B, CS2B and CS3 are in active mode and R/W and RS=H, stored data in display data RAM is latched in output register. When CS1B to CS3 is in active mode and R/W=H, RS=L, status data (busy check) can read out.

To read the contents of display data RAM, twice access of read instruction is needed. In first access, data in display data RAM is latched into output register. In second access, MPU can read data which is latched. That is to read the data in display data RAM, it needs dummy read. But status read is not needed dummy read.

RS	R/W	Function
L	L	Instruction
	H	Status read (busy check)
H	L	Data write (from input register to display data RAM )
	H	Data read (from display data RAM to output register)

**4. Reset**

The system can be initialized by setting RSTB terminal at low level when turning power on, receiving instruction from MPU. When RSTB becomes low, following procedure is occurred.

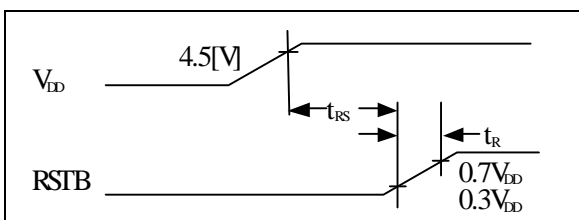
1. Display off
2. Display start line register become set by 0. (Z-address 0)

While RSTB is low, No instruction except status read can be accepted. Therefore, execute other instructions after making sure that DB4= (clear RSTB) and DB7=0 (ready) by status read instruction.

The conditions of power supply at initial power up are shown in table 1.

Table 1. Power Supply Initial Conditions

Item	Symbol	Min	Typ	Max	Unit
Reset Time	$t_{RS}$	1.0	-	-	us
Rise Time	$t_R$	-	-	200	ns



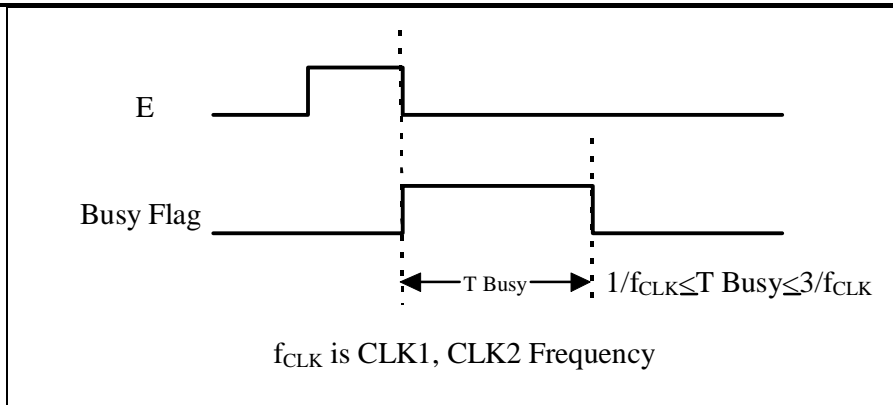
**5. Busy flag**

Busy flag indicates that NT7108C is operating or no operating. When busy flag is high, NT7108C is in internal operating .

When busy flag is low, NT7108C can accept the data or instruction.

DB7 indicates busy flag of the NT7108C.

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**6. Display On/Off Flip-Flop**

The display on/off flip-flop makes on/off the liquid crystal display. When flip-flop is reset (logical low), selective voltage or non-selective voltage appears on segment output terminals. When flip-flop is set (logic high), non selective voltage appears on segment output terminals regardless of display RAM data.

The display on/off flip-flop can changes status by instruction. The display data at all segments disappear while RSTB is low.

The status of the flip-flop is output to DB5 by status read instruction.

The display on/off flip-flop synchronized by CL signal.

**7. X Page Register**

X page register designates pages of the internal display data RAM.

Count function is not available. An address is set by instruction.

**8. Y address counter**

Y address counter designates address of the internal display data RAM. An address is set by instruction and is increased by 1 automatically by read or writes operations of display data.

**9. Display Data RAM**

Display data RAM stores a display data for liquid crystal display. To indicate on state dot matrix of liquid crystal display, write data 1. The other way, off state, writes 0.

Display data RAM address and segment output can be controlled by ADC signal.

ADC=H => Y-address 0: S1~Y address 63: S64

ADC=L => Y-address 0: S64~Y address 63: S1

ADC terminal connect the  $V_{DD}$  or  $V_{SS}$ .

**10. Display Start Line Register**

The display start line register indicates of display data RAM to display top line of liquid crystal display.

Bit data (DB<0.5>) of the display start line set instruction is latched in display start line register. Latched data is transferred to the Z address counter while FRM is high, presetting the Z address counter.

It is used for scrolling of the liquid crystal display screen.

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