LCD Module Technical Specification

Part No: **MG 938NB-LW-01**

Crystal

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Approved Date : 9 Jun 2008

Table of Contents

1.0   General Description

The **MG 938NB-LW-01** (**RoHS Compliance)** is a compact LCD module capable of displaying graphics and characters. It has been developed specially for instrumentation applications. The module has the following features:

Display Format	240 (L) X 64 (W) Dots
LCD Type	STN, Blue background
Display Mode	Negative, Transmissive
Driving Method	1/64 Duty Cycle, 1/9 Bias
Viewing Direction	6 O'clock
LCD Controller LSI	T6963C
Back lighting	LED + Light guide (White color)

2.0   Product Specifications

2.1 Mechanical Data

Item	Specifications	Unit
Outline Dimensions	200.0 (L) x 66.0 (W) x 17.6 (H) max (note)	mm
Viewing Area	132.00 (L) x 39.00 (W)	mm
Image Area	127.17 (L) x 33.89 (W)	mm
Number Of Dots	240 (L) x 64 (W)	-
Dot Size	0.50 (L) x 0.50 (W)	mm
Dot Pitch	0.53 (L) x 0.53 (W)	mm

Note: the interface pin height not included.

2.2 Absolute Maximum Ratings

VDD – Supply Voltage   Unless otherwise specified, V_{SS}= 0V

Item	Symbol	Min.	Max.	Unit
Supply Voltage (Logic)	V_{DD}-V_{SS}	0	6.5	V
Supply Voltage (LCD Drive)	V_{DD} - V_o	0	22	V
Input Voltage	V_{IN}	0	V_{DD}	V
Static Electricity (Note 1)	-	-	100	V
Operating Temperature (Note 2)	T_{OPR}	0	+50	°C
Storage Temperature (Note 2)	T_{STR}	-20	+60	°C
Humidity (Note 2)	-	-	85	%RH
Corrosive Gas	-	Not Acceptable	Not Acceptable	-

Note 1. Test Condition: Connect a charged 200pF capacitor to interface pins.

Note 2. No dew condensation observes.

2.3 Electrical Characteristics

Unless otherwise specified V_{SS} = 0V, V_{DD} = 5V, Ta = 25°C

Item	Symbol	Min.	Typ.	Max.	Unit
Logic Voltage	V_{DD}-V_{SS}	4.75	5.0	5.25	V
Logic Current (Note 1)	I_{DD}	-	12.5	25.0	mA
Contrast Adjust Voltage (Note 2)	V_o- V_{DD}	-12.0	-12.9	-13.8	V
Contrast Adjust Current (Note 1)	I_o	-	-3.0	-5.0	mA
V_{IN} High (Note 3)	V_{IH}	V_{DD} –2.2	-	V_{DD}	V
V_{IN} Low (Note 3)	V_{IL}	0	-	0.8	V
V_{OUT} High (Note 3)	V_{OH}	V_{DD}-0.3	-	V_{DD}	V
V_{OUT} Low (Note 3)	V_{OL}	0	-	0.3	V
Backlight Supply Voltage	V_{AK}		24.0		V
LED forward current	If		40.0		mA
Luminous intensity (note 4)	L		140		cd/m^2

Note 1: The display pattern is all pixels 'ON', VDD-Vo=12.9V.
Note 2: Contrast adjust voltage may fluctuate $\pm 0.3V$ by each module.
Note 3: Apply to terminals WR, RD, CE, C/D, RST, FS, D0~D7.
Note 4 : Luminous intensity is measured on display center of module surface.

2.4 Electro-Optical Characteristics

V_{DD} = 5V, Ta = 25 °C, Duty = 1/64, Bias = 1/9

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Contrast ratio	CR	$\theta=0°,\phi=270°$	-	3.5	-	-
Viewing Angle	θ	CR>1.5, $\phi=270°$	-35		+40	°
Viewing Angle	ϕ	CR >1.5, $\theta=35°$	225	270	315	°
Response Time	tr			130	200	ms
	td	-	-	70	140	ms

tr – the time at the moment when luminance rises up to 90% of the full light level;
td – the time at the moment when it drops to 10%.

*Figure 2.1: <u>Viewing Angle and Optimum Viewing Area</u>*
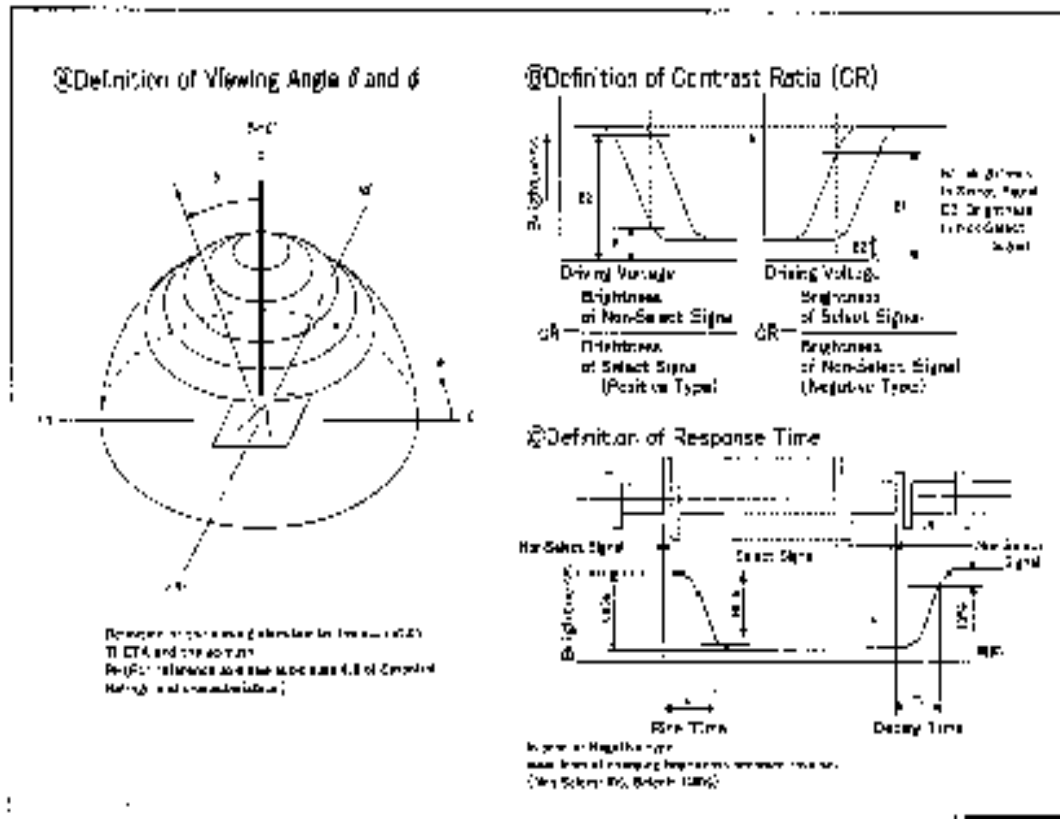
2.5 Interface Pin Assignments

Note : On the drawing containing interface pins, the table below also apply.

Pin No.	Symbol	Level	Function
1	FGND	-	Frame Ground
2	GND	-	Power Supply (VSS, 0V)
3	V_{DD}	-	Power Supply for Logic +5v
4	V_o	-	Negative Voltage for LCD contrast adjustment
5	/WR	L	Write Signal ("L" active)
6	/RD	L	Read Signal ("L" active)
7	/CE	L	Chip Enable Signal ("L" active)
8	C/D	H/L	Write Mode H: Command L: Data Write Read Mode H: Status Read L: Data Read
9	NC	-	No Connection
10	/RESET	-	Reset Signal ("L" Reset)
11	D0	H/L	
12	D1	H/L	
13	D2	H/L	
14	D3	H/L	8-bit Data
15	D4	H/L	
16	D5	H/L	
17	D6	H/L	
18	D7	H/L	
19	FS	H/L	Font Switch VDD = 6 x 8 dots VSS = 8 x 8 dots
20	NC	-	No Connection

2.6 Backlighting Characteristics

Backlight structure : LED NSCW505CT (5pcs on each side) + DF20 light guide with pattern in between covered with reflector (Toray) and diffuser(8B2B).
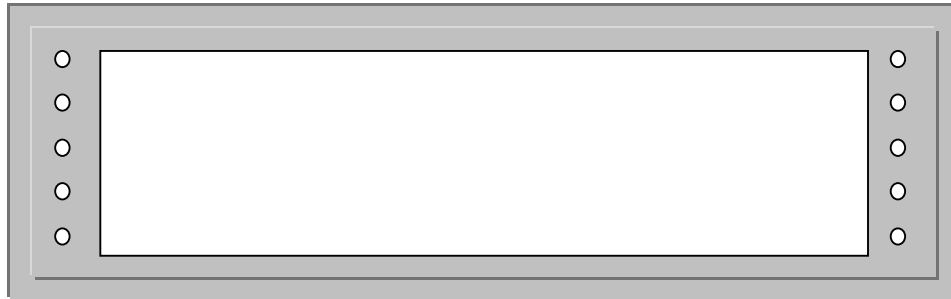
Backlight circuit : Resistors used as shown below is 300 ohm x 2, to limit the current at about 20mA flowing through every single LED, when 24V is supplied.
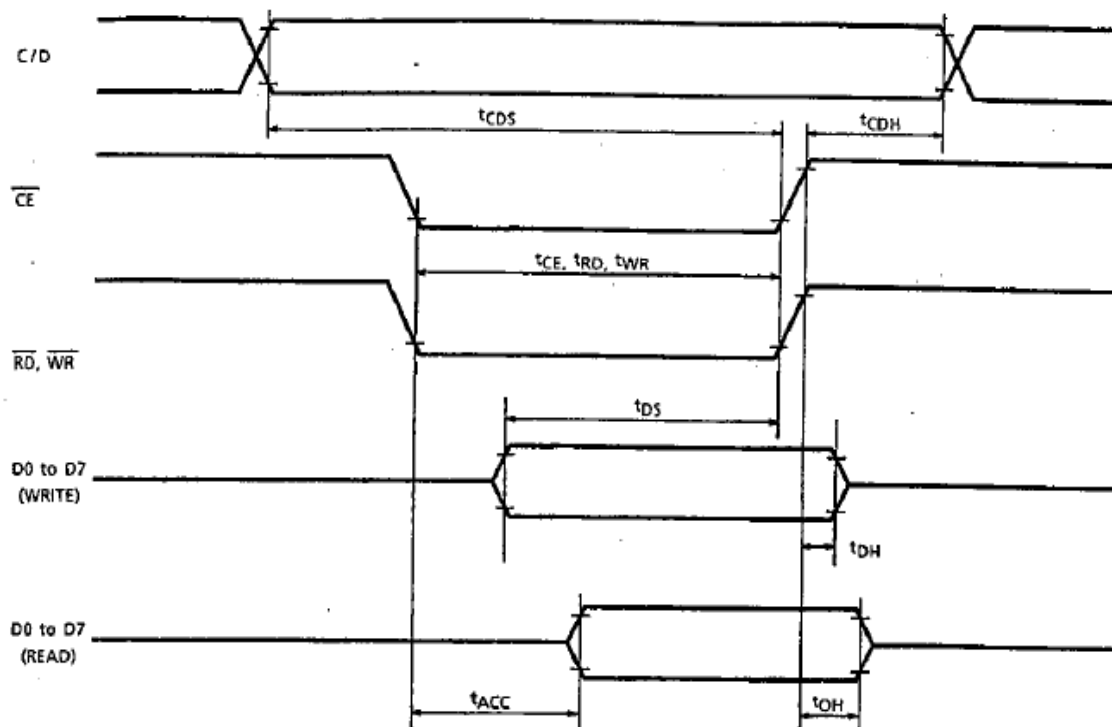
LED K   LED A
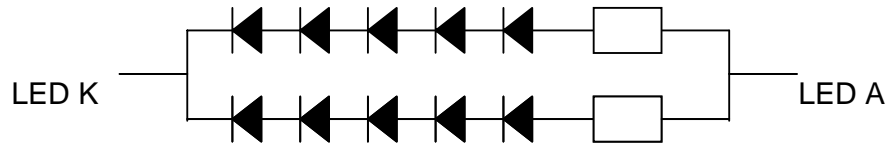
3.0 Interface Timing

- *System Bus Read/Write Characteristics*

(VDD = 5V $\pm$ 5%, Ta = 0 to +60 $^\circ$C)

Parameter	Symbol	Min	Max	Unit
C/D Set Up Time	tCDS	100	-	ns
C/D Hold Time	tCDH	10	-	ns
CE, RD, WR Pulse Width	tCE, tRD, tWR	80	-	ns
Data Set Up Time	tDS	80	-	ns
Data Hold Time	tDH	40	-	ns
Access Time	tACC	-	150	ns
Output Hold Time	tOH	10	50	ns

Figure 3.1: MPU Bus Timing
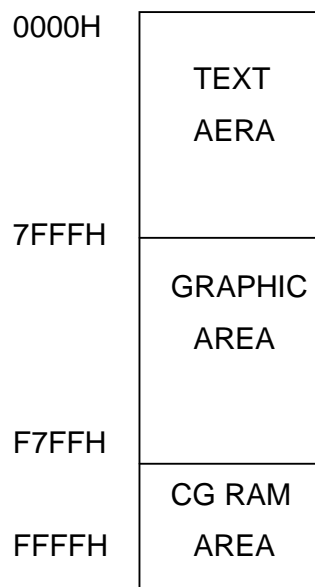
4.0   Interface Control

4.1 Function Description

4.1.1 RAM Interface

The external RAM is used for store display data (text, graphic, external CG).

It can be freely allocate text data, Graphic data, and external CG data in memory area (64KB max.).

- Example

```
0000H  ┌──────────┐
       │          │
       │   TEXT   │
       │   AERA   │
       │          │
7FFFH  ├──────────┤
       │          │
       │ GRAPHIC  │
       │  AREA    │
       │          │
F7FFH  ├──────────┤
       │ CG RAM   │
FFFFH  │  AREA    │
       └──────────┘
```

4.1.2 Flowchart of Communication with MPU

1) Status Read

   Before sending data (read/write), it is necessary to check the status.

   Status can be read from data lines:

   - RD   L
   - WR   H
   - CE   L
   - C/D   H
   - D0 ~ D7   Status word

Status word format is following:

D0	STA0	Check capability of command execution	0: Disable 1: Enable
D1	STA1	Check capability of data read/write	0: Disable 1: Enable
D2	STA2	Check capability of auto mode data read	0: Disable 1: Enable
D3	STA3	Check capability of auto mode data write	0: Disable 1: Enable
D4	STA4	Note used	
D5	STA5	Check capability of controller operation	0: Disable 1: Enable
D6	STA6	Error flag. Using screen peek/copy command	0: No error 1: Error
D7	STA7	Check the condition blink	0: Display off 1: Normal display

Note 1: It is necessary to check STA0 and STA1 at the same time. The error is happened when sending data at executing command.

Note 2: The status check will be enough to check STA0 / STA1.

Note 3: STA2/STA3 are valid in auto mode STA0/STA1 are invalid.
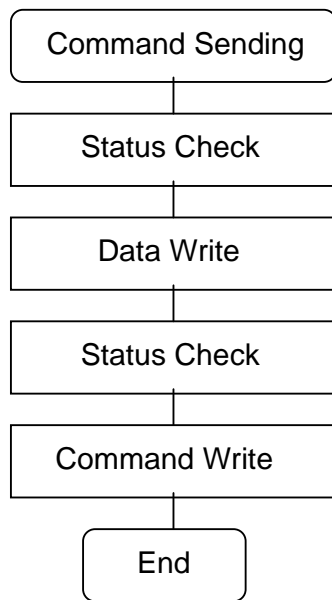
Status Check Flow
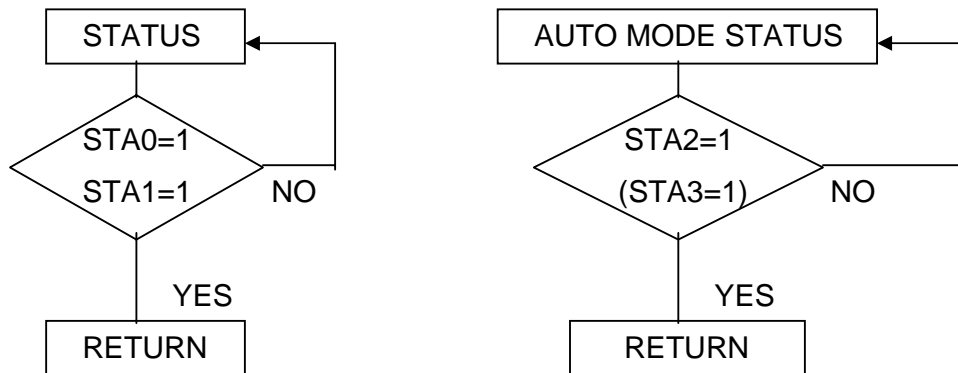
Note 4: It is impossible to save status check in the case of command of MSB0. To have the delay time cannot be save status check. The interrupt of hardware is happened at the end of lines. If command of MSB0is sent in this period, the command executing is waited. The state of waiting doesn't be known without checking status. The sending next command or data is disregarded or rewrites data of waiting command.
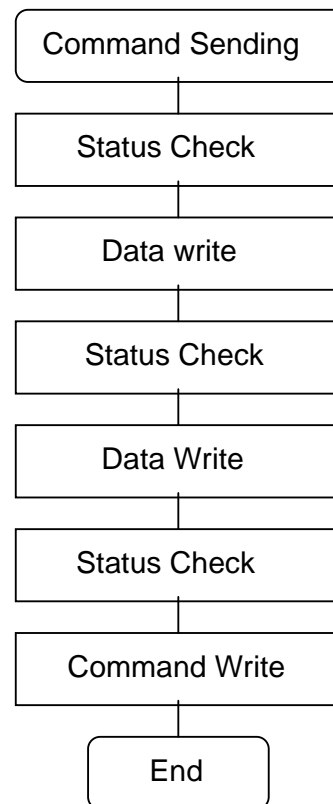
2) DATA SET

In T6963C, the data have been set and command executes.

The order of procedure of command sending

1. The case of 1 data   2. The case of 2 data

```
┌─────────────────────┐          ┌─────────────────────┐
│  Command Sending    │          │  Command Sending    │
└──────────┬──────────┘          └──────────┬──────────┘
┌──────────┴──────────┐          ┌──────────┴──────────┐
│    Status Check     │          │    Status Check     │
└──────────┬──────────┘          └──────────┬──────────┘
┌──────────┴──────────┐          ┌──────────┴──────────┐
│     Data Write      │          │     Data write      │
└──────────┬──────────┘          └──────────┬──────────┘
┌──────────┴──────────┐          ┌──────────┴──────────┐
│    Status Check     │          │    Status Check     │
└──────────┬──────────┘          └──────────┬──────────┘
┌──────────┴──────────┐          ┌──────────┴──────────┐
│   Command Write     │          │     Data Write      │
└──────────┬──────────┘          └──────────┬──────────┘
┌──────────┴──────────┐          ┌──────────┴──────────┐
│        End          │          │    Status Check     │
└─────────────────────┘          └──────────┬──────────┘
                                 ┌──────────┴──────────┐
                                 │   Command Write     │
                                 └──────────┬──────────┘
                                 ┌──────────┴──────────┐
                                 │        End          │
                                 └─────────────────────┘
```

Note: In case of over 2 data sending, the last data (or last 2 data) is valid.

4.1.3 Character Code Map

ROM CODE 0101

4.*2   Display Control Instructions*

4.2.1   Detailed Explanation

1. Register Set

CODE	HEX.	FUNCTION	D1	D2
00100001	21H	Cursor Pointer Set	X ADRS	Y ADRS
00100010	22H	Offset Register Set	Data	00H
00100100	24H	Address Pointer Set	Low ADRS	High ADRS

1) Cursor Pointer Set

The position of cursor is specified by X ADRS, Y ADRS. The cursor position is moved only by this command. The cursor pointer doesn't have the function of increment and decrement. The shift of cursor is set by this command. X ADRS, Y ADRS   are specified following.

X ADRS   00H ~ 4FH (Lower 7 bits are valid)
Y ADRS   00H ~ 1FH (Lower 5 bits are valid)

2) Offset Register Set

The offset register is used to determine external character generator RAM area. T6963C has 16 bits address lines as follow.

MSB   LSB

ad15	ad14	ad13	ad12	ad11	ad10	ad9	ad8	ad7	ad6	ad5	ad4	ad3	ad2	ad1	ad0

The upper 5 bits (ad15 ~ ad11) are determined by offset register. The middle 8 bits (ad10 ~ ad13) are determined by character code. The lower 3 bits (ad2 ~ ad0) are determined by vertical counter. The lower 5 bits of D1 (data) are valid.
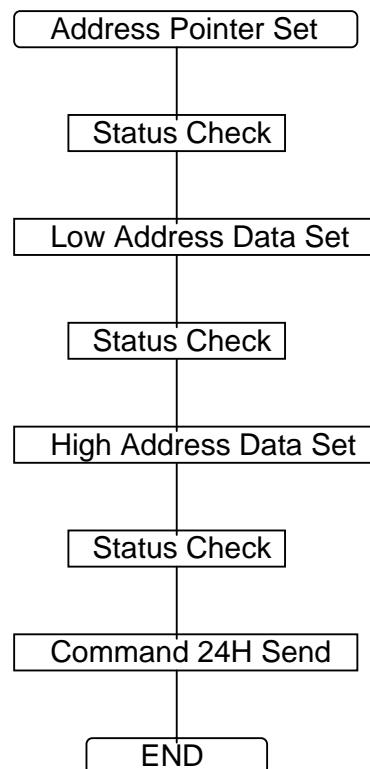The data format of external character generator RAM.

Relationship of display RAM address and offset register

Data of offset register	CG RAM HEX. address (start-end)
00000B	0000 – 07FFH
00001B	0800 – 0FFFH
00010B	1000 – 17FFH
11100B	E000 – E7FFH
11101B	E800 – EFFFH
11110B	F000 – F7FFH
11111B	F800 -- FFFFH

3) Address Pointer Set

The address pointer set command is used to indicate the start address for writing (or reading) to external RAM.

The flow chart address pointer set command

```
      Address Pointer Set
             |
         Status Check
             |
      Low Address Data Set
             |
         Status Check
             |
      High Address Data Set
             |
         Status Check
             |
      Command 24H Send
             |
            END
```

2. Control Word Set

CODE	HEX.	FUNCTION	D1	D2
01000000	40H	Text home address set	Low add.	High add.
01000001	41H	Text area set	Columns	00H
01000010	42H	Graphic home address set	Low add.	High add.
01000011	43H	Graphic area set	Columns	00H

The home address and column size are defined by this command.

1) Text Home Address Set

The starting address of external display RAM for Text display is defined by this command. The text home address shows the left end and most upper position.

The relationship of external display RAM address and display position

TH		TH + CL
TH + TA		TH + TA+ CL
(TH + TA) +TA		TH + 2TA + CL
(TH + 2TA) + TA		TH + 3TA + CL
:		:
TH + (n - 1)TA		TH + (n -1)TA + CL

TH: Text home address

TA: Text area number (columns)

CL: Columns are fixed by hardware. (Pin-programmable)

2) Graphic Home Address Set

The starting address of external display RAM for Graphic display is defined by this command. The graphic home address shows the left end most upper line.

The relationship of external display RAM address and display position

GH		GH + CL
GH + GA		GH + GA+ CL
(GH + GA) +GA		GH + 2GA + CL
(GH + 2GA) + GA		GH + 3GA + CL
:		:
GH + (n - 1)GA		GH + (n -1)GA + CL

3) Text Area Set

The columns of display are defined by the hardware setting. This command can be used to adjust columns of display.

4) Graphic Area Set

The columns of display are defined by the hardware setting. This command can be used to adjust columns of graphic display.

The address in graphic area can be continuous and RAM area can be used without ineffective area, if graphic area is defined the same number as the actual column number of LCD display.

3. Mode Set

CODE	FUNCTION	OPERAND
1000X000	"OR" Mode	-
1000X001	"EXOR" Mode	-
1000X011	"AND" Mode	-
1000X100	"TEXT ATTRIBUTE" Mode	-
10000XXX	Internal Character Generator Mode	-
10001XXX	External Character Generator Mode	-

The display mode is defined by this command. The display mode doesn't have changed until to send next this command. Logically "OR", "EXOR", "AND" of text and graphic display can be displayed.

When internal character generator mode is selected, character code 00H ~ 7FH are selected from built-in character generator ROM. The character code 80H ~ FFH are automatically selected external character generator RAM.

Note: Only text display is attributed, because attribute data is located in graphic RAM area.

Attribute function

"Reverse display", "Character blink" and "Inhibit" are called "Attribute". The attribute data is written in the graphic area defined by Control word set command. The mode set command selects text display only and graphic display cannot be displayed.

The attribute data for the 1st character in text area is written at the 1st 1byte in graphic area. And attribute data of nth character is written at the nth 1byte in graphic area. Attribute function is defined as follow.
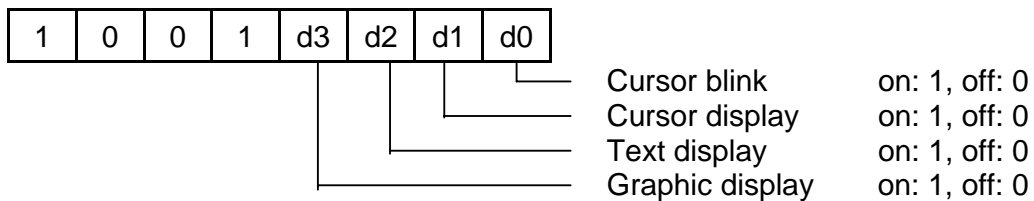
Attribute RAM 1 byte :

X	X	X	X	d3	d2	d1	d0

d3	d2	d1	d0	FUNCTION
0	0	0	0	Normal display
0	1	0	1	Reverse display
0	0	1	1	Inhibit display
1	0	0	0	Blink of normal display
1	1	0	1	Blink of reverse display
1	0	2	2	Blink of inhibit display

X: Don't care

4. Display Mode

CODE	FUNCTION	OPERAND
10010000	Display off	-
1001XX10	Cursor on, blink off	-
1001XX11	Cursor on, blink on	-
100101XX	Text on, graphic off	-
100110XX	Text off, graphic on	-
100111XX	Text on, graphic on	-

1	0	0	1	d3	d2	d1	d0

Cursor blink   on: 1, off: 0
Cursor display   on: 1, off: 0
Text display   on: 1, off: 0
Graphic display   on: 1, off: 0

Note: It is necessary to turn on "Text display" and "Graphic display" in following case.
1) Combination of text/ graphic display
2) Attribute function

5. Cursor Pattern Select

CODE	FUNCTION	OPERAND
10100000	1 line cursor	-
10100001	2 lines cursor	-
10100010	3 lines cursor	-
10100011	4 lines cursor	-
10100100	5 lines cursor	
10100101	6 lines cursor	
10100110	7 lines cursor	
10100111	8 lines cursor	-

When cursor display is ON, this command selects the cursor pattern from 1 line to 8 line. The cursor address is defined by Cursor Pointer Set command.

6. Write Display Data

CODE	HEX.	FUNCTION	OPERAND
10110000	B0H	Data auto write set	-
10100110	B1H	Data auto read set	
10100111	B2H	Auto reset	-

This command is convenient to send full screen data from external display RAM. After setting auto mode, "Data write (or read)" command is not necessary between each data. "Data auto write (or read)" command should follow the "Address pointer set" and address pointer is automatically increment by +1 after each data. After sending (or receiving) all data "Auto reset" is necessary to return normal operated in the auto mode.

Note: Status check for auto mode (STA2, STA3 should be checked between each data). Auto reset should be performed after checking STA3=1 (STA2=1).

7. Data Read Write

CODE	HEX.	FUNCTION	OPERAND
11000000	C0H	Data write and ADP increment	Data
11000001	C1H	Data read and ADP increment	-
11000010	C2H	Data write and ADP decrement	Data
11000011	C3H	Data read and ADP decrement	-
11000100	C4H	Data write and ADP nonvariable	Data
11000101	C5H	Data read and ADP nonvariable	-

This command is used for data write from MPU to external display RAM, and data read from external display RAM to MPU. Data write/data read should be executed after setting address by address pointer set command. Address pointer can be automatically increment or decrement by setting this command.

Note: This command is necessary for each 1-byte data.

8. Screen Peek

CODE	HEX.	FUNCTION	OPERAND
11100000	E0H	Screen peek	-

This command is used to transfer displayed 1-byte data to data stack, and this 1 byte data can be read from MPU by data access. The logical combination data of text and graphic display on LCD screen can be read by this command.

The status (STA6) should be checked just after "Screen peek" command. If the address determined by "address pointer set" command is not in graphic area, this command ignored and status flag (STA6) is set.

9. Screen Copy

CODE	HEX.	FUNCTION	OPERAND
11101000	E8H	Screen copy	-

This command is used to copy displayed 1 line data to graphic area. The start point of 1 line data in the screen is determined by the address pointer.

Note: In attribute function, this command is invalid.

(Because attribute data is in the graphic area.)

10. Bit Set/Reset

CODE	FUNCTION	OPERAND
11110XXX	bit reset	-
11111XXX	bit set	-
1111X000	bit 9 (LSB)	-
1111X001	bit 1	-
1111X010	bit 2	-
1111X011	bit 3	-
1111X100	bit 4	-
1111X101	bit 5	-
1111X110	bit 6	-
1111X111	bit 7 (MSB)	-

This command is used to set or reset a bit of 1 byte is specified by address pointer. Plural bits in the 1-byte data cannot be set/reset at a time.

4.2.2 Summary

COMMAND	CODE	D1	D2	FUNCTION
REGISTER SET	00100001	X address	Y address	Cursor pointer set
	00100010	Data	00H	Offset register set
	00100100	Low address	High address	Address pointer set
CONTROL WORD SET	01000000	Low address	High address	Text home address set
	01000001	Columns	00H	Text area set
	01000010	Low address	High address	Graphic home address set
	01000011	Columns	00H	Graphic area set
MODE SET	1000X000	-	-	"OR" mode
	1000X001			"EXOR" mode
	1000X011			"AND" mode
	1000X100			"Text attribute" mode
	10000XXX			Internal CG ROM mode
	10001XXX			External CGRAM mode
DISPLAY MODE	10010000	-	-	Display off
	1001XX10			Cursor on, blink off
	1001XX11			Cursor on, blink on
	100101XX			Text on, graphic off
	100110XX			Text off, graphic on
	100111XX			Text on, graphic on
CURSOR PATTERN SELECT	10100000	-	-	1 line cursor
	10100001			2 line cursor
	10100010			3 lines cursor
	10100011			4 lines cursor
	10100100			5 lines cursor
	10100101			6 lines cursor
	10100110			7 lines cursor
	10100111			8 lines cursor
DATA AUTO READ/WRITE	10110000	-	-	Data auto write set
	10110001			Data auto read set
	10110010			Auto reset
DATA READ / WRITE	11000000	Data	-	Data write and ADP increment
	11000001	-	-	Data read and ADP increment
	11000010	Data	-	Data write and ADP decrement
	11000011	-	-	Data read and ADP decrement
	11000100	Data	-	Data write and ADP nonvariable
	11000101	-	-	Data read and ADP nonvariable
SCREEN PEEK	11100000	-	-	Screen peek
SCREEN COPY	11101000	-	-	Screen copy
BIT SET/RESET	11110XXX	-	-	bit reset
	11111XXX			bit set
	1111X000			bit 0 (LSB)
	1111X001			bit 1
	1111X010			bit 2
	1111X011			bit 3
	1111X100			bit 4
	1111X101			bit 5
	1111X110			bit 6
	1111X111			bit 7 (MSB)

5.0   Reliability Specifications

5.1   Test Specimen

Unless otherwise specified, two specimens shall be taken from a normal production lot and subject to each of the tests specified herein.

5.2   Operational State

Unless otherwise specified, test specimens shall be in Operational State during all tests meaning power and signals shall be applied.

An auto cycle test pattern routine shall be applied to the test specimens.
The pattern include all dots on, even dots on, odd common on, even segment on and odd segment on

5.3   Acceptance Criteria

Test specimens shall not exhibit any sign of uneven contrast, flickering, missing, shorted pixels or unusual patterns for the entire duration of the auto cycle test pattern.

5.4   Reliability Test Description

5.4.1 Test Condition

- Unless specified otherwise, test will be conducted under the following condition:

    Temperature : $20 \pm 5\ °C$
    Humidity   : $65 \pm 5\%$

- Unless otherwise specified, test specimens shall be in Operational State during all tests meaning power and signals shall be applied.

    An auto cycle test pattern routine shall be applied to the test specimens.
    The pattern include all dots on, even dots on, odd common on, even segment on and odd segment on.

- Unless specified otherwise, test will be conducted to the product itself without putting in a container.

- In case of related to deterioration such as shock test, it will be conducted only once.

5.4.2 4 - Corner Environmental Stress Test

Test specimens shall be subjected to a 4 states environmental stress test as follows :
- State 1 : 0 ± 2 °C,
- State 2 : $+50 \pm 2$ °C, 20 ± 5% RH
- State 3 : 0 ± 2 °C,
- State 4 : $+50 \pm 2$ °C, 80 ± 5% RH

Each state shall last 24 hours including ramp-up/down periods not less than 1 hour each.

5.4.3 Vibration Test

Test specimens shall be subjected to vibration as follows:
- Amplitude: 1.0 mm
- Frequency: Sweeping from 10 Hz to 55 Hz and then back to 10 Hz
- No. Of Cycles: one cycle 60 sec. To 3 axes for each 15 min.
- Mounting: Test specimens are to be secured to the vibrating table via the appropriate fasteners at the 4 corners of the test specimens.

5.4.4 Drop Test

The quantity of test specimens shall be the maximum prescribed per the designated packing carton. Each test specimen shall be packed in its respective prescribed packaging medium and in accordance to the prescribed Packaging Instructions Pk-938-01.
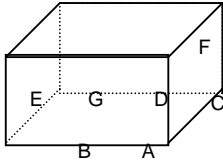
The packed specimens shall be dropped once on:

Corner: A

Edge: B, C, D

Face: E, F, G

- Height of drop 60 cm onto concrete floor

After the completion of all 10 drops, all specimens shall be subjected to 100% mechanical inspection, followed by 5 cycles of the auto cycle test pattern routine.

5.4.5 Storage Test

High temperature storage: Function test shall be conducted after storage 96 hours in the non-operational state at +60 °C $\pm$ 2 °C, and 4hours storage at normal temperature and humidity (65 $\pm$ 5 % RH).

Low temperature storage: Function test shall be conducted after storage 96 hours in the non-operational state at -20 °C $\pm$ 2 °C, and 4hours storage at normal temperature and humidity (65 $\pm$ 5 % RH).

5.4.6 Damp Proof Test

Condition 50°C $\pm$ 2°C, 90~95%RH, 96 hours (non-operation state)
No dew condensation to be observed.
Returned under normal temperature and humidity for 5 hours.

5.4.7 ESD (Electro - Static Discharge) Immunity

Test specimens shall meet the standards of IEC61000-4-2:1995, at minimum Air Discharge Voltage level of 12 kV (installed in customer's device). Test specimens will not exhibit any hard (unrecoverable) error after test.

5.4.8   MTBF (Mean Time between Failure)

When operating under conditions as follows:

- Operating Voltage: V_{OP} = 5.0 V DC
- Temperature: Ta = 25 °C
- Relative Humidity: 65%
- MTBF: 50,000 hours (minimum)

Notes: For Vibration Test, ESD Immunity Test & Drop Test, reports will only be provided upon requests from customer. The cost involved in generating the report will be fully responsible by the customer.

6.0   Inspection Specifications

6.1   Inspection Level

This section specifies failure criteria, and failure ate for the LCD Assembly. The methods of determine the MTBF and the failure rate is to be established. All series production LCD assembly shall be tested 100% prior to shipment for further processing. The LCD assembly shall be considered a failing unit when it no longer meets any of the requirements stated in this specification.

The display assembly shall be considered a failing unit when any one of the following occur:

- The back light output drops down to 60% luminance (FOS) of the initial value.
- Any screen defects which belong to the failure of the LCD electrical circuitry.
- Any lead or wire breaking caused by corrosion and of mechanical/thermal shock.
- Wire/cables/connectors/glass plates failure in any manner affecting form, fit function or reliability.
- Bad viewing angle in wrong position.
- Segment shorts (automatic test).
- Unreliable contacts (flickering of entire display or of individual segments).
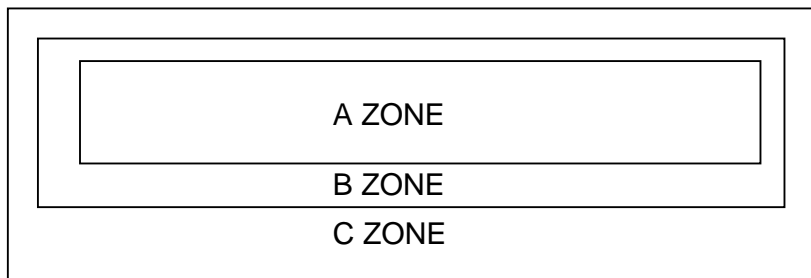
Class	Contents	AQL %
Critical Defects	No display Turn On, Inappropriate SEG Turn On, Functional Defect	.25
Major Defects	Electrical, optical, mechanical parameters out of specs without affecting functions.	1
Minor Defects	Black spots, Foreign substances, Pin hole segment, Deformation, Scratches (polarizer), Air Bubbles between glass & polarizer, Color variations, Polarizer dirt, Other visual defects.	2.5

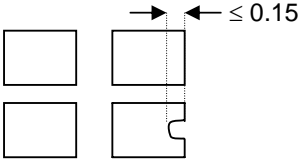### *6.2   Appearance Standards*
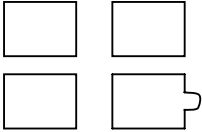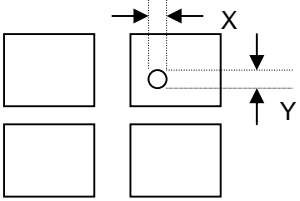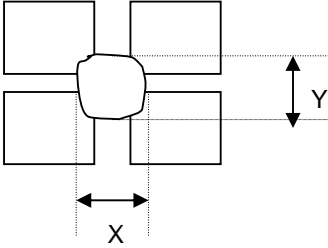
1) Inspection Conditions

The module shall be inspected under 40 W white fluorescent light. The distance between the eyes and the sample shall be 30 cm. All directions for inspecting the samples should be within 45° against the vertical of the LCD.

2) Appearance Specifications

```
+-----------------------------------------------------+
|  +-----------------------------------------------+  |
|  |  +-----------------------------------------+  |  |
|  |  |                                         |  |  |
|  |  |               A ZONE                    |  |  |
|  |  |                                         |  |  |
|  |  +-----------------------------------------+  |  |
|  |               B ZONE                          |  |
|  +-----------------------------------------------+  |
|                  C ZONE                             |
+-----------------------------------------------------+
```

a) A ZONE: active display area,

b) B ZONE: area from outside of "A ZONE" to insight edge of metal holder,

c) C ZONE: rest parts.

No	Item	Criteria		Acceptable Number		
1	Black and White Spots, Foreign Substances	a) Round shape		**A**	**B**	**C**
		(D : Diameter, mm)	$D \leq 0.1$	NC	NC	NC
			$0.10 < D \leq 0.20$	3	5	NC
			$0.20 < D \leq 0.25$	2	3	NC
			$0.25 < D \leq 0.30$	0	1	NC
			$0.30 < D$	0	0	NC
		b) Line shape		**A**	**B**	**C**
		(L: Length, mm) (W: Width, mm)	$W \leq 0.03$	NC	NC	NC
			$L \leq 2.0, W \leq 0.05$	3	3	NC
			$L \leq 1.0, W \leq 0.1$	3	3	NC
			$W > 0.1$	0	0	NC
		c) Total defects shall not exceed five				

2	Air Bubbles		A	B	C
		D ≤ 0.30	NC	NC	NC
		0.30< D ≤ 0.40	3	NC	NC
		0.40 < D ≤ 0.60	2	3	NC
		0.60 < D	0	0	NC
		(D : Mean Diameter, mm)			
		Total defects shall not exceed five			
3	Shape of Dot	a) Dot Shape (with dent) → ← ≤ 0.15 As per the sketch of left hand	One / Dot Five / Cell		
		b) Dot Shape (with projection) Should not be connected to next dot			
		c) Pin Hole X Y (X+Y)/2 ≤ 0.2mm (less than 0.1mm is no counted)			
		d) Deformation Y X (X+Y)/2 ≤ 0.2mm However, each dot shall be remained more than 50% of original dot area.	1		

4	Polarizer Scratches	In A+B zone S>0.21mm not allowed; In C zone S>1 mm not allowed. (S=SQR(l + w); l = length; w = width)	
5	Polarizer Dirt's	If the stains are removed easily from LCD Panel surface, the module is not defective.	
6	Complex foreign substances defects	Black Spot, Line shaped foreign substances or air bubbles between glass & polarizer should be 5pcs maximum in total	
7	Distance between different foreign substances	$D \leq 0.2$	20mm or more
		$D > 0.2$	40mm or more

7.0   Precautions for Use of LCD Module

7.1   Handling Precautions

The display panel is made of glass. Do not subject it to a mechanical shock by dropping it from a high place.

If the display panel is damaged and the liquid crystal substance inside it leaks out, be sure not to get any in your mouth. If the substance comes into contact with your skin or clothes, please immediately wash it off using soap and water.

Do not apply excessive force on the surface of display or the adjoining areas of LCD module since this may cause the color tone or vary.

To prevent destruction of the elements by static electricity, be careful to maintain an optimum work environment.
• Please be sure to ground human body and electric appliances during work.
• It is preferable to use conductive mat on table and wear cotton clothes or
   conduction processed fiber.
• Slowly peel off protective film since static electricity may be generated.

7.2 Storage Precautions

When storing the LCD module, avoid exposure to direct sunlight or to the light of fluorescent lamps. Keep the LCD module in bags provided to prevent static electricity charging under low temperature (0 °C to 25 °C) / normal humidity conditions (avoid high temperature / high humidity and low temperature below 0°C).

If storage condition is not satisfactory, display (especially polarizer) may be deteriorated or soldering I/O terminals may become difficult (some oxide is generated at I/O terminals plating).

7.3 Design Precautions

The absolute maximum ratings represent the rated value beyond which LCD module cannot exceed. When LCD module is used in excess conditions, their operating characteristics may be adversely affected.

The liquid crystal display exhibits temperature dependency characteristics, be sure to use the LCD module within the specified range.

To prevent the occurrence of erroneous operation caused by noise, attention must be paid to satisfy the V_{IL}, V_{IH} specification values.

Power On/Off Sequence: Theoretically, proper power on/off sequence is needed to avoid any lifetime restrictions caused by DC component supplied to the LCD panel. However, This is not considered in the preliminary designs.

To prevent LCD module being damaged by erroneous input, connector with polarized locating pegs is recommended as the 20 way interface connector.

8.0 Warranty

This product has been manufactured to your company's specifications as a part for use in your company's general electronic products. It is guaranteed to perform according to delivery specifications. For any other use apart from general electronic equipment, we cannot take responsibility if the product is used in medical devices, nuclear power control equipment, aerospace equipment, fire and security systems, or any other applications in which there is a direct risk to human life and where extremely high levels of reliability are required. If the product is to be used in any of the above applications, we will need to enter into a separate product liability agreement.

1. We cannot accept responsibility for any defect, which may arise from additional manufacturing of the product (including disassembly and reassembly), after product delivery.
2. We cannot accept responsibility for any defect, which may arise after the application of strong external force to the product.
3. We cannot accept responsibility for any defect, which may arise due to the application of static electricity after the product has passed your company's acceptance inspection procedures.
4. We cannot accept responsibility for intellectual property of a third party, which may arise through the application of our product to your assembly with exception to those issues relating directly to the structure or method of manufacturing of our product.
5. Optrex will not be held responsible for any quality guarantee issue for defect products judged as Optrex-origin longer than two years from Optrex production or one year from Optrex, Optrex America, Optrex Europe delivery which every comes later.

Mean Time Between Failure for MG 938NB-LW-01

P/No.	Description	Qty. (n)	F (a)	n x a
L-938-01	LCDP	1	10	10
P-938-03	PCB	1	0.2	0.2
Z-817-01	Zebra (long)	1	504	504
Z-817-03	Zebra (short)	3	504	1512
T6963CFG-0101(C)	IC, LCD Controller	1	300	300
A625308AM-70SUF	IC, SRAM	1	183	183
S6B0086X01-COCX	IC Die, Driver	4	300	1200
LM324MX/NoPB	IC, Amp	1	50	50
CSAC4.91MGCA-TC	Resonator	1	9	9
Chip resistors	Resistors	8	3.5	28
Chip capacitors	Capacitors	13	1	13
NSCW505CT	LED, White	10	0.47	4.7

Reflow		437	0.2	87.4
Soldering (20pin connector & bezel ground)		21	1	21
COB		320	0.8	256

Total (n x a)		4178.3

Failure Rate (a) = No. of failure / Billon Hours

Failure in Time (FIT) = (n x a) x 10^{-9}

MTBF = 1 / FIT

$= 1 / (4178.3 \times 10^{-9})$

= 239, 332 hrs