Densitron

TFT DISPLAY MODULE

Product Specification

Customer	Standard	
Product Number	DMT024QVNUNT0-2C	
Customer Part Number		
Customer Approval		**Date:**

Internal Approvals		
Product Mgr	Doc. Control	Electr. Eng
Luo Luo	Luo Luo	David Hardman
Date: 07/01/18	**Date: 07/01/18**	**Date: 07/01/18**

Revision Record

Rev.	Date	Page	Chapt.	Comment	ECR no.
1.0	19-Dec-17	All	All	Initial Release An upgrade version of ex-DET024QVF1H-C	ECN8025

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1.0 Main Features

Item	Contents
Screen Size	2.4” Diagonal
Display Format	240 x RGB x 320 Dots
N° of Colour	262K
Active Area	36.72 mm (H) x 48.96 mm (V)
LCD Type	TFT
Mode	IPS Transmissive / Normally Black
Viewing Direction	Full view
Interface	80-series CPU 8/9/16/18 bit selectable
Driver IC	ST7789V
Backlight Type	LED
Operating Temperature	-20°C ~ +70°C
Storage Temperature	-30°C ~ +80°C
RoHS compliant	Yes

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2.0 Mechanical Specification

2.1 Mechanical Characteristics

Item	Characteristic	Unit
Display Format	240 x RGB x 320 Dots	Dots
Overall Dimensions	42.72 mm (H) x 60.4 mm (V) x 1.93 mm (D)	mm
Active Area	36.72 mm (H) x 48.96 mm (V)	mm
pixel Pitch	153 (H) x 153 (V)	µm
Weight	9	g

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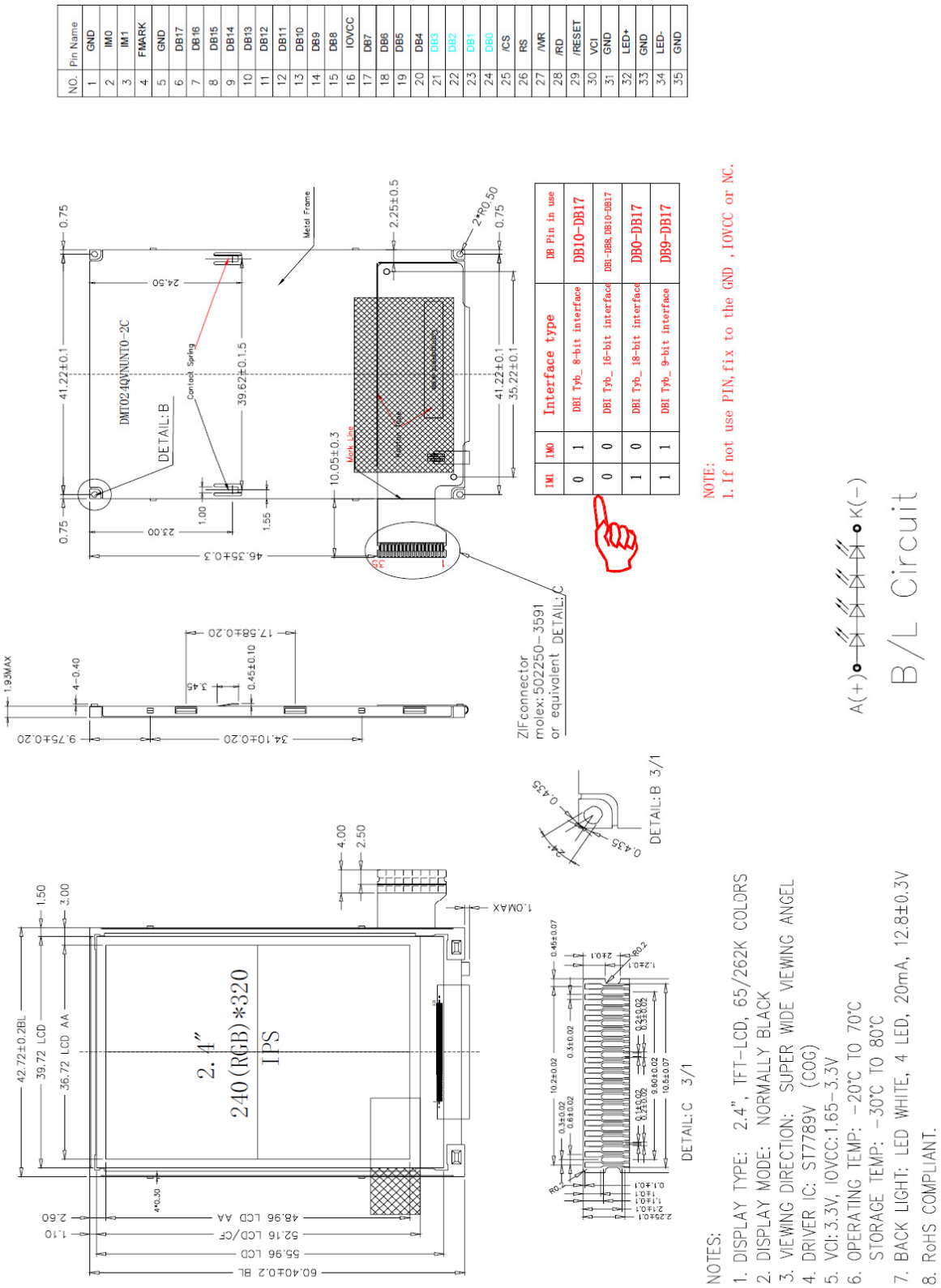
2.2 Mechanical Drawing



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3.0 Electrical Specification

3.1 Absolute Maximum Ratings

Item	Symbol	Condition	Min	Max	Unit	Note
Power Supply Voltage	VCI		-0.3	4.6	V	
Digital Interface Supply Voltage	IOVCC		-0.3	4.6	V	
Operating Temperature	TOP		-20	70	°C	1
Storage Temperature	TST		-30	80	°C	1,2,3

Note 1. 90 % RH Max for Ta<50 °C, and 60% RH for Ta≥50°C.
Note 2. In case of below 0°C, the response time of liquid crystal (LC) becomes slower and the colour of panel becomes darker than normal one. Level of retardation depends on temperature, because of LC's characteristic.
Note 3. Only operation is guaranteed at operating temperature. Contrast, response time, another display quality are evaluated at +25°C.

3.2 Electrical Characteristics

Item	Symbol	Condition	Min	Typ	Max	Unit	Note
Supply Voltage	VCI	Ta=25˚C	2.4	2.8	3.3	V	
Digital Interface Supply Voltage	IOVCC	Ta=25˚C	1.65	1.8	3.3	V	
Input Voltage for Logic	VIH		0.7 IOVCC	-	IOVCC	V	
	VIL		GND	-	0.3 IOVCC	V	
Output Voltage for Logic	VOH		0.8 IOVCC	-	IOVCC	V	
	VOL		GND	-	0.2 IOVCC	V	
Current Consumption	IDD		-	8.5	-	mA	1

Note 1: The specified power consumption is under the conditions of VCI=2.8V, FV=60Hz.

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3.3 Interface Pin Assignment

3.3.1 TFT Pin Assignment

Recommended connector: MOLEX 51296-5093

<table>
<tr><th>No.</th><th>Symbol</th><th>Function</th></tr>
<tr><td>1</td><td>GND</td><td>Ground</td></tr>
<tr><td>2</td><td>IM0</td><td rowspan="2"><table>
<tr><th rowspan="2">IM1</th><th rowspan="2">IM0</th><th rowspan="2">Interface mode 80-series</th><th colspan="2">DB Pin in use</th></tr>
<tr><th>Register/Content</th><th>GRAM</th></tr>
<tr><td>0</td><td>0</td><td>CPU 16-bit Interface II</td><td>D[8:1]</td><td>D[17:10]
D[8:1]</td></tr>
<tr><td>0</td><td>1</td><td>CPU 8-bit I/F II</td><td>D[17:10]</td><td>D[17:10]</td></tr>
<tr><td>1</td><td>0</td><td>CPU 18-bit I/F II</td><td>D[8:1]</td><td>D[17-0]</td></tr>
<tr><td>1</td><td>1</td><td>CPU 9 bit I/F II</td><td>D[17:10]</td><td>D[17:9]</td></tr>
</table></td></tr>
<tr><td>3</td><td>IM1</td></tr>
<tr><td>4</td><td>FMARK (TE)</td><td>Frame head pulse signal (leave it Open if not used)</td></tr>
<tr><td>5</td><td>GND</td><td>Ground</td></tr>
<tr><td>6</td><td>DB17</td><td rowspan="10">Data bus

(connect unused pin(s) to VSS)</td></tr>
<tr><td>7</td><td>DB16</td></tr>
<tr><td>8</td><td>DB15</td></tr>
<tr><td>9</td><td>DB14</td></tr>
<tr><td>10</td><td>DB13</td></tr>
<tr><td>11</td><td>DB12</td></tr>
<tr><td>12</td><td>DB11</td></tr>
<tr><td>13</td><td>DB10</td></tr>
<tr><td>14</td><td>DB9</td></tr>
<tr><td>15</td><td>DB8</td></tr>
<tr><td>16</td><td>IOVCC</td><td>Digital power supply</td></tr>
<tr><td>17</td><td>DB7</td><td rowspan="8">Data bus

(connect unused pin(s) to VSS)</td></tr>
<tr><td>18</td><td>DB6</td></tr>
<tr><td>19</td><td>DB5</td></tr>
<tr><td>20</td><td>DB4</td></tr>
<tr><td>21</td><td>DB3</td></tr>
<tr><td>22</td><td>DB2</td></tr>
<tr><td>23</td><td>DB1</td></tr>
<tr><td>24</td><td>DB0</td></tr>
<tr><td>25</td><td>/CS (CSX)</td><td>Chip select signal active low</td></tr>
<tr><td>26</td><td>RS (DCX)</td><td>Display data (RS=H) / Command selection (RS=L)</td></tr>
<tr><td>27</td><td>/WR (WRX)</td><td>Write signal active low</td></tr>
<tr><td>28</td><td>/RD (RDX)</td><td>Read signal active low</td></tr>
<tr><td>29</td><td>/RESET (RESX)</td><td>Reset signal active low</td></tr>
<tr><td>30</td><td>VCI</td><td>Analogue power supply</td></tr>
<tr><td>31</td><td>GND</td><td>Ground</td></tr>
<tr><td>32</td><td>LED+</td><td>LED power supply (+)</td></tr>
<tr><td>33</td><td>GND</td><td>Ground</td></tr>
<tr><td>34</td><td>LED-</td><td>LED power supply (-)</td></tr>
<tr><td>35</td><td>GND</td><td>Ground</td></tr>
</table>

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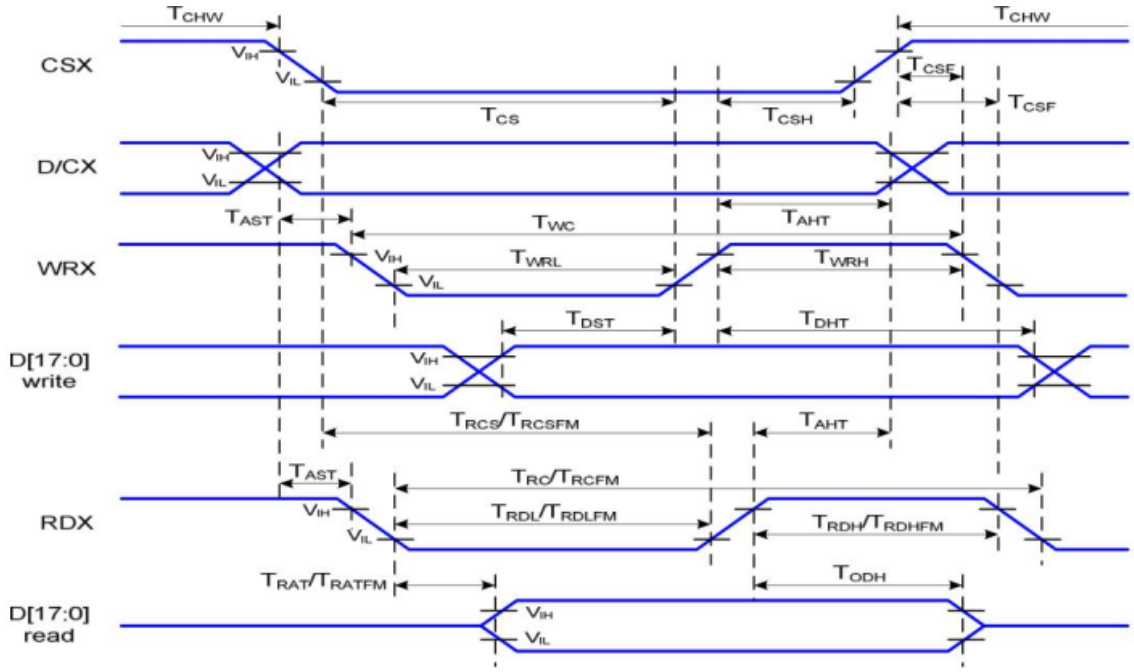
3.4 Timing Characteristics

Please refer to ST7789V datasheet for more information

3.4.1 Display 8080 Series MPU Parallel Interface Timing Characteristics



Signal	Symbol	Parameter	Min	Max	Unit	Description
D/CX	T_{AST}	Address setup time	0		ns	-
	T_{AHT}	Address hold time (Write/Read)	10		ns	
CSX	T_{CHW}	Chip select "H" pulse width	0		ns	-
	T_{CS}	Chip select setup time (Write)	15		ns	
	T_{RCS}	Chip select setup time (Read ID)	45		ns	
	T_{RCSFM}	Chip select setup time (Read FM)	355		ns	
	T_{CSF}	Chip select wait time (Write/Read)	10		ns	
	T_{CSH}	Chip select hold time	10		ns	
WRX	T_{WC}	Write cycle	66		ns	
	T_{WRH}	Control pulse "H" duration	15		ns	
	T_{WRL}	Control pulse "L" duration	15		ns	
RDX (ID)	T_{RC}	Read cycle (ID)	160		ns	When read ID data
	T_{RDH}	Control pulse "H" duration (ID)	90		ns	
	T_{RDL}	Control pulse "L" duration (ID)	45		ns	
RDX (FM)	T_{RCFM}	Read cycle (FM)	450		ns	When read from frame memory
	T_{RDHFM}	Control pulse "H" duration (FM)	90		ns	
	T_{RDLFM}	Control pulse "L" duration (FM)	355		ns	
D[17:0]	T_{DST}	Data setup time	10		ns	For CL=30pF

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	T_{DHT}	Data hold time	10		ns	
	T_{RAT}	Read access time (ID)		40	ns	
	T_{RATFM}	Read access time (FM)		340	ns	
	T_{ODH}	Output disable time	20	80	ns	

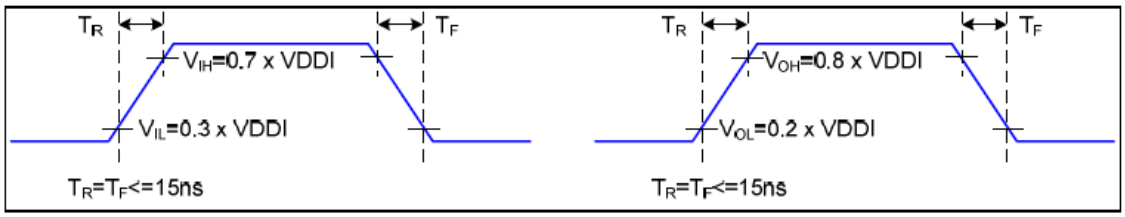

Figure 2 Rising and Falling Timing for I/O Signal

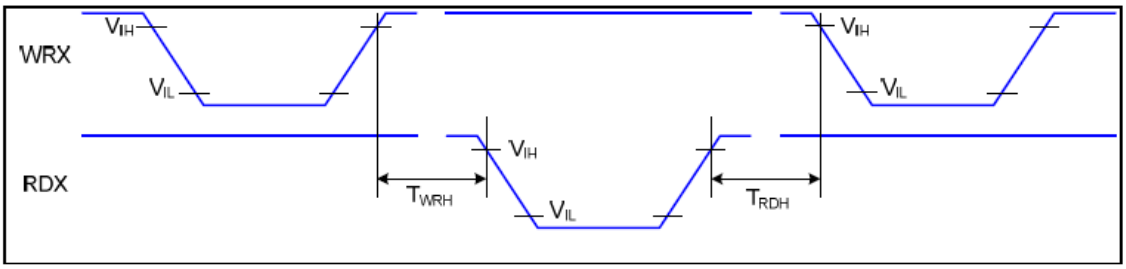

Figure 3 Write-to-Read and Read-to-Write Timing

Note: The rising time and falling time (Tr, Tf) of input signal and fall time are specified at 15 ns or less. Logic high and low levels are specified as 30% and 70% of VDDI for Input signals.

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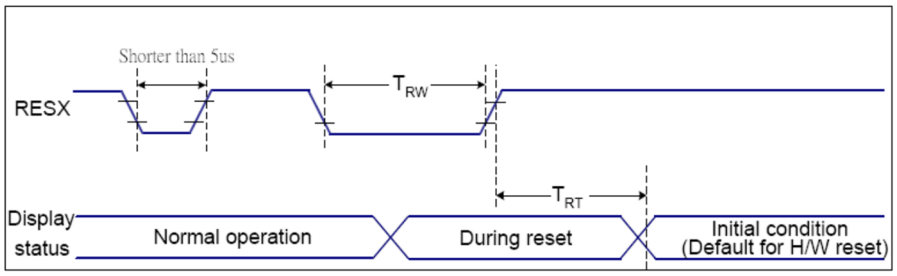
3.4.2 Reset Timing Characteristics



VDDI=1.65 to 3.3V, VDD=2.4 to 3.3V, AGND=DGND=0V, Ta=-30 ~ 70 ℃

Related Pins	Symbol	Parameter	MIN	MAX	Unit
RESX	TRW	Reset pulse duration	10	-	us
	TRT	Reset cancel	-	5 (Note 1, 5)	ms
				120 (Note 1, 6, 7)	ms

Notes:

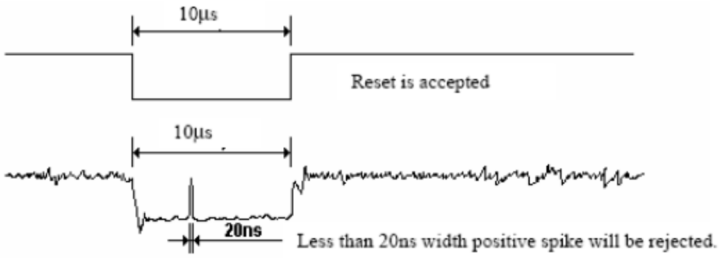
1. The reset cancel includes also required time for loading ID bytes, VCOM setting and other settings from NVM (or similar device) to registers. This loading is done every time when there is HW reset cancel time (tRT) within 5 ms after a rising edge of RESX.

2. Spike due to an electrostatic discharge on RESX line does not cause irregular system reset according to the table below:

RESX Pulse	Action
Shorter than 5us	Reset Rejected
Longer than 9us	Reset
Between 5us and 9us	Reset starts

3. During the Resetting period, the display will be blanked (The display is entering blanking sequence, which maximum time is 120 ms, when Reset Starts in Sleep Out –mode. The display remains the blank state in Sleep In –mode.) and then return to Default condition for Hardware Reset.

4. Spike Rejection also applies during a valid reset pulse as shown below:



5. When Reset applied during Sleep In Mode.

6. When Reset applied during Sleep Out Mode.

7. It is necessary to wait 5msec after releasing RESX before sending commands. Also Sleep Out command cannot be sent for 120msec.

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4.0 Optical Specification

4.1 Optical Characteristics

Measuring instruments: LCD-5100, Eldim, Topcon BM-7
Driving condition: IOVCC = VCI = 2.8V, VSS = 0V
Backlight: IF=20mA
Measured temperature: Ta ＝ 25 ˚C

Item		Symbol	Condition	Min	Typ	Max	Unit	Note
Response Time		TR+TF	θ=Φ=0° Normal Viewing Angle	-	35	45	ms	2
Contrast Ratio		CR		640	800	-		3
Viewing Angle	Left	θL	CR ≥ 10	-	80	-	deg	4
	Right	θR		-	80	-	deg	
	Up	ϕU		-	80	-	deg	
	Down	ϕD		-	80	-	deg	
Colour Chromaticity	Red	Rx	CR ≥ 10	0.613	0.633	0.653	-	5
		Ry		0.316	0.336	0.356	-	
	Green	Gx		0.302	0.322	0.342	-	
		Gy		0.585	0.605	0.625	-	
	Blue	Bx		0.126	0.146	0.166	-	
		By		0.028	0.048	0.068	-	
	White	Wx		0.270	0.310	0.350	-	
		Wy		0.291	0.331	0.371	-	
Centre Brightness				420	500	-	cd/m²	6
Brightness Distribution				80	-	-	%	7

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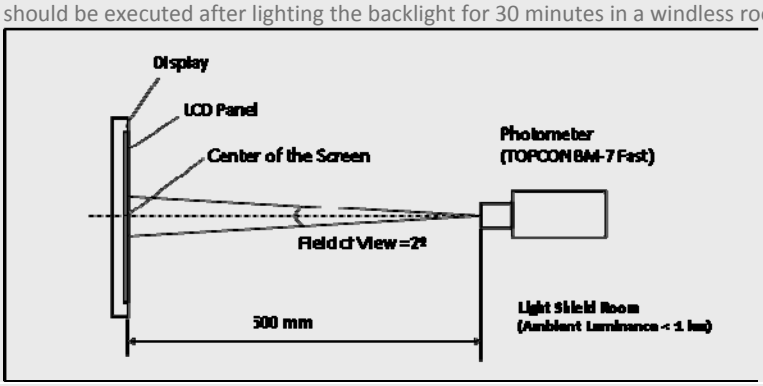
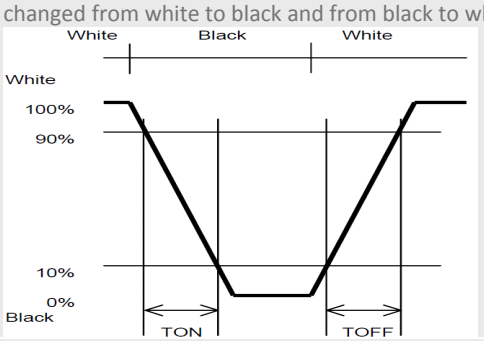
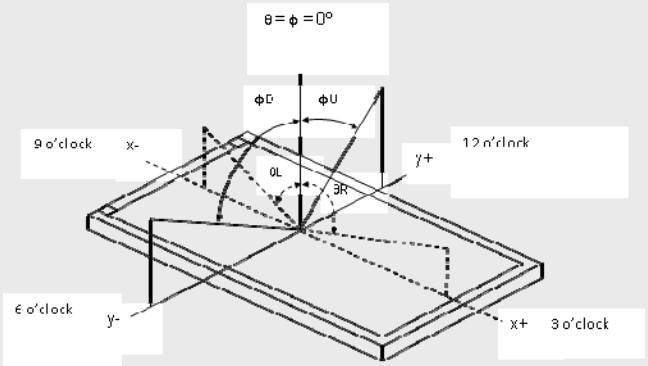
4.1.1 Test Method

Note	Item	Test Method
1	Setup	The display should be stabilised at a given temperature for 30 minutes to avoid abrupt temperature change during measuring. In order to stabilise the luminance, measurements should be executed after lighting the backlight for 30 minutes in a windless room. 
2	Response time	Measure output signal waveform by the luminance meter when raster of window pattern is changed from white to black and from black to white. 
3	Contrast ratio	Measure maximum brightness and minimum brightness at the centre of the screen by displaying raster or window pattern. Then calculate the ratio between these two values. Contrast Ratio (CR) = Brightness of unselected position (white) / Brightness of selected position (black)
4	Viewing angle Horizontal θ Vertical Ø	Move the luminance meter from right to left and up and down and determinate the angles where contrast ratio is 10 
5	Colour chromaticity	Measure chromaticity coordinates x and y of CIE1931 colorimetric system
6	Centre brightness	Measure the brightness at the centre of the screen
7	Brightness distribution	(Brightness distribution) = 100 x B/A % A: max. brightness of the 9 points B: min. brightness of the 9 points

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5.0 Backlight Specification

5.1 LED Driving Conditions

Item	Symbol	Condition	Min	Typ	Max	Unit
Forward Current	IF	Ta=25 °C	-	20	-	mA
Forward Voltage	VF	Ta= 25°C	3.0*4	3.2*4	3.4*4	V
Reverse Voltage	VR	Ta= 25°C	-		30	V
Power Consumption	PBL	Ta= 25°C	-	256	-	mW
LED life time	Hr		-	50k	-	hour

Note:

- The lifetime of the LED is defined as a period till the brightness of the LED decreases to the half of its initial value.
- This figure is given as a reference purpose only, and not a guarantee.
- This figure is estimated for an LED operating alone.
  The performance of an LED may differ when assembled as a monitor together with a TFT panel due to different environmental temperature.
- Estimated lifetime could vary on a different temperature and usually higher temperature could reduce the life significantly.

5.2 LED Circuit

BLU CIRCUIT DIAGRAM

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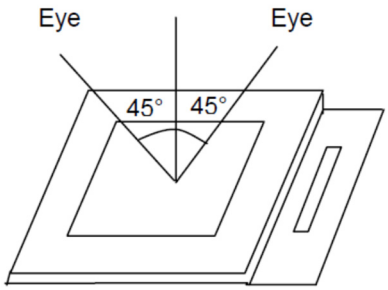
6.0 Quality Assurance Specification

6.1 Delivery Inspection Standards



6.1.1 Inspection Conditions

Inspection distance: 30 cm ± 2 cm
Viewing angle: ±45°

6.1.2 Environmental Conditions

Ambient temperature: 25°C ±5°C
Ambient humidity: 65±10% RH
Ambient illumination: 300~700 lux

6.1.3 Sampling Conditions

1. Lot size: quantity of shipment lot per model
2. Sampling method:

Sampling Plan		GB/T 2828-2003
		Normal inspection, Class II
AQL	Major Defect	0.65%
	Minor Defect	1.5%

No	Items to be inspected	Criteria	Classification of defects
1	Functional defects	1) No display, Open or miss line 2) Display abnormally, Short 3) Backlight no lighting, abnormal lighting. 4) TP no function	Major
2	Missing	Missing component	
3	Outline dimension	Overall outline dimension beyond the drawing is not allowed	
4	Colour tone	Colour unevenness, refer to limited sample	Minor
5	Spot Line defect	Light dot ， Dim spot, Polarizer Bubble; Polarizer accidented spot.	
6	Soldering appearance	Good soldering, peeling off is not allowed.	

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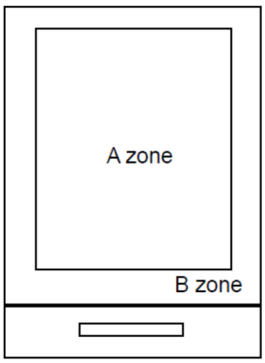
6.1.4 Definition of Area

A zone: active area
B zone: viewing area



6.1.5 Basic Principle

A set of samples to indicate the limit of acceptable quality level shall be discussed should a dispute occur.

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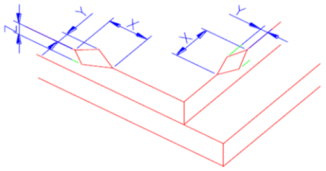
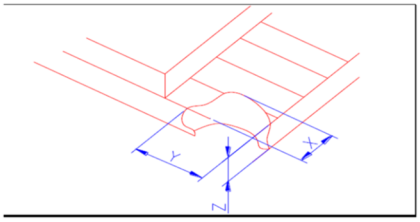
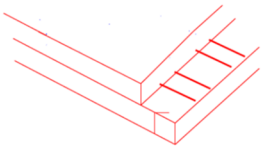
6.1.6 Inspection Criteria

<table>
<tr><th>Number</th><th>Items</th><th>Criteria(mm)</th></tr>
<tr><td rowspan="3">1.0 LCD Crack/Broken

NOTE:
X: Length
Y: Width
Z: Height
L: Length of ITO,
T: Height of LCD</td><td>(1) The edge of LCD broken</td><td> 
<table><tr><th>X</th><th>Y</th><th>Z</th></tr><tr><td>≤3.0mm</td><td><Inner border line of the seal</td><td>≤T</td></tr></table></td></tr>
<tr><td>(2)LCD corner broken</td><td> 
<table><tr><th>X</th><th>Y</th><th>Z</th></tr><tr><td>≤3.0mm</td><td>≤L</td><td>≤T</td></tr></table></td></tr>
<tr><td>(3) LCD crack</td><td> 
Crack
Not allowed</td></tr>
</table>

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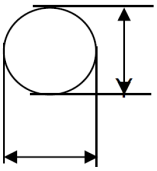
2.0

Spot defect



X

Φ=(X+Y)/2

① light dot（LCD/TP/Polarizer black/white spot , light dot, pinhole, dent, stain）

Zone / Size (mm)	Acceptable Qty		
	A	B	C
Φ≤0.10	Ignore		Ignore
0.10<Φ≤0.20	3(distance≧10mm)		
0.20<Φ≤0.25	2		
Φ>0.3	0		

②Dim spot（LCD/TP/Polarizer dim dot, light leakage、dark spot）

Zone / Size (mm)	Acceptable Qty		
	A	B	C
Φ≤0.1	Ignore		Ignore
0.10<Φ≤0.20	3(distance≧10mm)		
0.20<Φ≤0.25	2		
Φ>0.3	0		

③ Polarizer accidented spot

Zone / Size (mm)	Acceptable Qty		
	A	B	C
Φ≤0.2	Ignore		Ignore
0.3<Φ≤0.5	2(distance≧10mm)		
Φ>0.5	0		

④Pixel bad points（light dot，Dim dot, color dot）

Zone / Size (mm)	Acceptable Qty		
	A	B	C
Φ≤0.1	Ignore		Ignore
0.15<Φ≤0.2	2(distance≧10mm)		
Φ>0.2	0		

⑤ Polarizer Bubble

Zone / Size (mm)	Acceptable Qty		
	A	B	C
Φ≤0.2	Ignore		Ignore
0.3<Φ≤0.4	3(distance≧10 m)		
0.4<Φ≤0.5	2		
Φ>0.5	0		

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<table>
<tr><td>3.0</td><td>Line defect (LCD/TP /Polarizer backlight black/white line, scratch, stain)</td><td>
<table>
<tr><td rowspan="2">Width(mm)</td><td rowspan="2">Length(mm)</td><td colspan="3">Acceptable Qty</td></tr>
<tr><td>A</td><td>B</td><td>C</td></tr>
<tr><td>Φ≤0.03</td><td>Ignore</td><td colspan="2">Ignore</td><td rowspan="3">Ignore</td></tr>
<tr><td>0.03<W≤0.04</td><td>L≤3.0</td><td colspan="2">N≤2</td></tr>
<tr><td>0.04<W≤0.05</td><td>L≤2.0</td><td colspan="2">N≤1</td></tr>
<tr><td>0.05<W</td><td colspan="4">Define as spot defect</td></tr>
</table>
</td></tr>
<tr><td>4.0</td><td>Electronic Components SMT</td><td>Not allow missing parts，solderless connection，cold solder joint，mis match，The positive and negative polarity opposite</td></tr>
<tr><td>5.0</td><td>Display color& Brightness</td><td>1. Color：Measuring the color coordinates, The measurement standard according to the datasheet or samples.
2. Brightness：Measuring the brightness of White screen, The measurement standard according to the datasheet or Samples.</td></tr>
<tr><td>6.0</td><td>LCD Mura</td><td>By 5% ND filter invisible.</td></tr>
</table>

Criteria (functional items)

Number	Items	Criteria (mm)
1	No display	Not allowed
2	Missing segment	Not allowed
3	Short	Not allowed
4	Backlight no lighting	Not allowed
5	TP no function	Not allowed

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6.1.7 Classification of Defects

Visual defects (except no or wrong label) are treated as minor defects, while electrical defects are treated as major defects.
Two minor defects are equal to one major defect in lot sampling inspection.

6.1.8 Identification / marking criteria

Any unit with illegible / wrong / double or no marking / label shall be rejected.

6.2 Dealing with Customer Complaints

6.2.1 Non-conforming analysis

Purchaser should supply Densitron with detailed data of non-conforming sample.
After accepting it, Densitron should complete the analysis in two weeks from receiving the sample.
If the analysis cannot be completed on time, Densitron must inform the purchaser.

6.2.2 Handling of non-conforming displays

If any non-conforming displays are found during customer acceptance inspection which Densitron is clearly responsible for, return them to Densitron.
Both Densitron and customer should analyse the reason and discuss the handling of non-conforming displays when the reason is not clear.
Equally, both sides should discuss and come to agreement for issues pertaining to modification of Densitron quality assurance standard.

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7.0 Reliability Specification

7.1 Reliability Tests

Test Item		Test Condition		Sample Size
Durability Test	High Temperature Operation	Ta= 70˚C	96h	3pcs
	Low Temperature Operation	Ta=-20˚C	96h	3pcs
	Temperature Cycle Operation	-20°C ←→ 70°C ON/OFF, 20 cycles. ON time over 10 seconds, OFF time over 10 seconds		3pcs
	High Temperature Storage	Tp= 80°C	96h	3pcs
	Low Temperature Storage	Tp= -30°C	96h	3pcs
	ESD Test	150pF, 330Ω, ±6KV (Contact)/±8KV (Air), 5 Points/panel, 10 times/point		3pcs
	Thermal Shock Resistance	The sample should be allowed to stand the following 5 cycles of operation: LTS for 30 minutes -> normal temperature for 5 minutes -> HTS for 30 minutes -> normal temperature for 5 minutes, as one cycle, then taking it out and drying it at normal temperature, and allowing it stand for 24 hours		3pcs
	Box Drop Test	1 Corner 3 Edges 6 faces, 66 cm (Medium Box)		1 box

Note: Ta=ambient temperature Tp= Panel temperature

Notes:
1. No dew condensation to be observed.
2. The function test shall be conducted after 4 hours storage at the normal temperature and humidity after removed from the test chamber.
3. No cosmetic or functional defects should be allowed.
4. Total current consumption should be less than twice the initial value.

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8.0 Handling Precautions

Safety

If the LCD panel breaks, be careful not to get the liquid crystal fluid in your mouth or in your eyes.
If the liquid crystal touches your skin or clothes, wash it off immediately using soap and plenty of water.

Mounting and Design

Place a transparent plate (e.g. acrylic, polycarbonate or glass) on the display surface to protect the display from external pressure. Leave a small gap between the transparent plate and the display surface.
When assembling with a zebra connector, clean the surface of the pads with alcohol and keep the surrounding air very clean.
Design the system so that no input signal is given unless the power supply voltage is applied.

Caution during LCD cleaning

Lightly wipe the display surface with a soft cloth soaked with Isopropyl alcohol, Ethyl alcohol or Trichlorotriflorothane.
Do not wipe the display surface with dry or hard materials that will damage the polariser surface.
Do not use aromatic solvents (toluene and xylene), or ketonic solvents (ketone and acetone).

Caution against static charge

As the display uses C-MOS LSI drivers, connect any unused input terminal to VDD or VSS. Do not input any signals before power is turned on. Also, ground your body, work/assembly table and assembly equipment to protect against static electricity.

Packaging

Displays use LCD elements, and must be treated as such. Avoid strong shock and drop from a height. To prevent displays from degradation, do not operate or store them exposed directly to sunshine or high temperature/humidity.

Caution during operation

It is indispensable to drive the display within the specified voltage limit since excessive voltage shortens its life. Direct current causes an electrochemical reaction with remarkable deterioration of the display quality. Give careful consideration to prevent direct current during ON/OFF timing and during operation. Response time is extremely delayed at temperatures lower than the operating temperature range while, at high temperatures, displays become dark. However, this phenomenon is reversible and does not mean a malfunction or a display that has been permanently damaged. If the display area is pushed on hard during operation, some graphics will be abnormally displayed but returns to a normal condition after turning off the display once. Even a small amount of condensation on the contact pads (terminals) can cause an electro-chemical reaction which causes missing rows and columns. Give careful attention to avoid condensation.

Storage

Store the display in a dark place where the temperature is 25°C ± 10°C and the humidity below 50%RH. Store the display in a clean environment, free from dust, organic solvents and corrosive gases. Do not crash, shake or jolt the display (including accessories).

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