



LMT028DHHFWL-NBN

LCD Module User Manual

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|---|----------------------------------|-----------------------------------|
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|---|----------------------------------|-----------------------------------|

| Rev. | Descriptions | Release Date |
|------|---|--------------|
| 0.1 | Preliminary new release | 2018-03-15 |
| 0.2 | Update description of /RD | 2018-11-21 |
| 0.3 | Update Terminal Functions | 2019-05-08 |
| 0.4 | Typing Correction | 2020-08-13 |
| 0.5 | Update 1.Basic Specifications,Change the BLEN description in 1.2 Terminal Functions,Change the Input High Voltage of 3.1 DC Characteristics,Delete the backlight control timing section | 2023-12-06 |

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1. Basic Specifications

| | |
|-------------------------|--|
| Screen Size(Diagonal) : | 2.8" |
| Active Area : | 57.6x43.2(mm) |
| Number of dots : | 320 x 240(RGB) |
| Pixel Pitch: | 0.18x0.18(mm) |
| Color Depth: | 65k colors |
| Display Technology : | a-Si TFT active matrix |
| Display Mode : | Normal White, Transmissive |
| Display Interface : | MCU_8bit |
| Viewing Direction : | 9 o'clock(Gray scale Inversion) (*1) 3 o'clock (*2) |
| Surface Treatment : | HC |
| Operating Temperature : | -20 ~ +70°C |
| Storage Temperature : | -30 ~ +80°C |

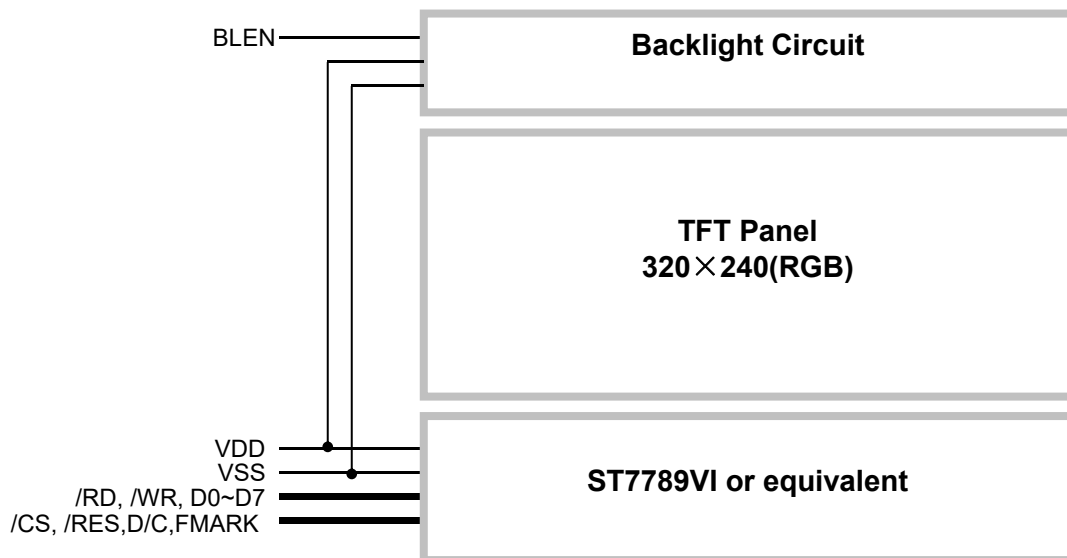
Note:

*1. For saturated color display content (eg. pure-red, pure-green, pure-blue, or pure-colors-combinations).

*2. For "color scales" display content.

*3. Color tone may slightly change by Temperature and Driving Condition.

1.1 Block Diagram



1.2 Terminal Functions

| Pin No. (K1) | Pin Name | I/O | Descriptions |
|--------------|----------|-----|---|
| 1 | VSS | P | Negative power supply,0V |
| 2 | VSS | | |
| 3 | BLEN | I | Backlight enable BLEN=L, turn off Backlight BLEN=H(*1), turn on Backlight PWM(*2) brightness control |
| 4 | VDD | P | Positive power supply |
| 5 | VDD | | |
| 6 | /RD | I | Read enable input, active low |
| 7 | /WR | I | Write enable input, active low |
| 8 | D/C | I | Register Select D/C=L, Transferring the Control Data D/C= H, Transferring the Display Data |
| 9 | /CS | I | Chip Select /CS=L, enable access to the LCD module /CS=H, disable access to the LCD module |
| 10 | D0 | I/O | Data Input |
| : | : | : | : |
| 17 | D7 | I/O | Data Input |
| 18 | /RES | I | Reset signal /RES = L, Initialization is executed /RES = H, Normal running. |
| 19 | FMARK | O | Displaying Timing Frame Signal |
| 20~28 | NC | - | - |

Note:

*1. The output driving current of the BLEN control I/O port must be greater than 2mA.

*2. The PWM frequency is between 200Hz and 10kHz.

2. Absolute Maximum Ratings

VDD =5V, VSS=0V, T_{OP}=25°C

| Items | Symbol | Min. | Max. | Unit | Condition |
|-----------------------|-----------------|------|------|------|-----------------|
| Supply Voltage | VDD | -0.3 | +5.5 | V | VSS= 0V |
| Input Voltage | V _{IN} | -0.3 | +4.6 | V | VSS = 0V |
| Operating Temperature | T _{OP} | -20 | +70 | °C | No Condensation |
| Storage Temperature | T _{ST} | -30 | +80 | °C | No Condensation |

Cautions:

Any Stresses exceeding the Absolute Maximum Ratings may cause substantial damage to the device. Functional operation of this device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect device reliability.

3. Electrical Characteristics

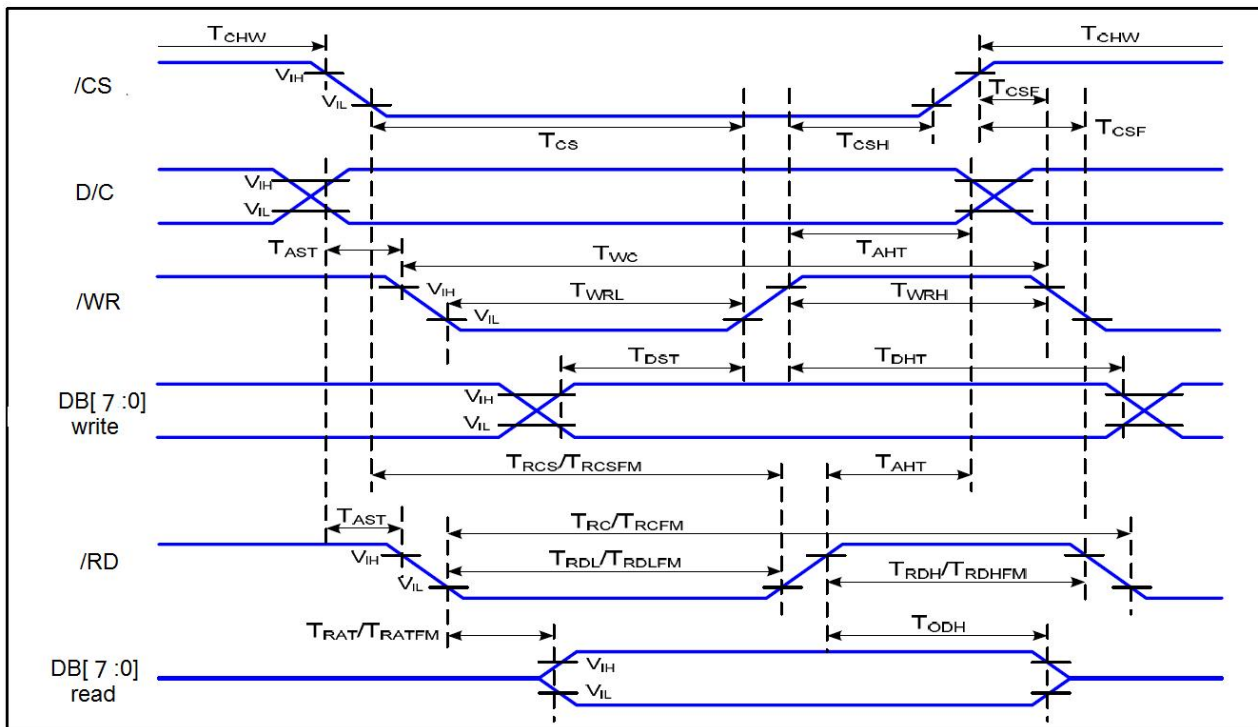
3.1 DC Characteristics

VDD=5V, VSS=0V, T_{OP}=25°C

| Items | Symbol | MIN. | TYP. | MAX. | Unit | Condition / Application Pin |
|--------------------|-----------------|------------|------|------------|------|-----------------------------|
| Operating Voltage | VDD | 4.8 | 5.0 | 5.2 | V | VDD |
| | IOVDD | 1.65 | 3.0 | 3.6 | V | I/O supply Voltage |
| Input High Voltage | V _{IH} | 0.8* IOVDD | - | IOVDD | V | /RES,D0~D7,/CS |
| Input Low Voltage | V _{IL} | 0 | - | 0.3* IOVDD | V | /RD,/WR,BLEN,D/C |
| Operating Current | I _{DD} | - | 74.5 | 85 | mA | Backlight are ON |
| | I _{DD} | - | 6.25 | 16 | mA | Backlight are OFF |

3.2 AC Characteristics

8080 Mode System Bus Timing



VDD =5V, VSS=0V, T_{OP}=25°C

| Signal | Symbol | Parameter | Spec. | | Unit | Description |
|---------|--------------------|-----------------------------------|-------|------|------|---|
| | | | Min. | Max. | | |
| D/C | T _{AST} | Address setup time | 5 | - | ns | - |
| | T _{AHT} | Address hole time(Write/Read) | 13 | - | | |
| /CS | T _{CHW} | Chip select "H" pulse width | 5 | - | ns | - |
| | T _{CS} | Chip select setup time(Write) | 20 | - | | |
| | T _{RCS} | Chip select setup time(Read ID) | 60 | - | | |
| | T _{RCSFM} | Chip select setup time(Read FM) | 460 | - | | |
| | T _{CSF} | Chip select wait time(Write/Read) | 13 | - | | |
| | T _{CSH} | Chip select hold time | 13 | - | | |
| /WR | T _{WC} | Write cycle | 86 | - | ns | - |
| | T _{WRH} | Control pulse "H" duration | 20 | - | | |
| | T _{WRL} | Control pulse "L" duration | 20 | - | | |
| DB[7:0] | T _{DST} | Data setup time | 13 | - | ns | For maximum CL=30pF For minimum CL=8pF |
| | T _{DHT} | Data hold time | 13 | - | | |
| | T _{RAT} | Read access time(ID) | - | 52 | | |
| | T _{RATFM} | Read access time(FM) | - | 442 | | |
| | T _{ODH} | Ouput disable time | 14 | 104 | | |
| /RD(ID) | T _{RC} | Read cycle(ID) | 208 | - | ns | When read ID data |
| | T _{RDH} | Control pulse "H" duration(ID) | 120 | - | | |
| | T _{RDL} | Control pulse "H" duration(ID) | 60 | - | | |
| /RD(FM) | T _{RCFM} | Read cycle(FM) | 585 | - | | When read from frame memory |
| | T _{RDHFM} | Control pulse "H" duration(FM) | 120 | - | | |
| | T _{RDLFM} | Control pulse "H" duration(FM) | 460 | - | | |

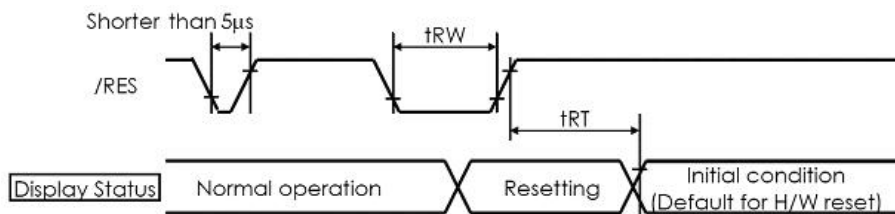
Note:

*1. Input signal rise/fall time should be less than 15ns .

*2. All timing is using 20% and 80% of VDD as the reference.

*3. Please refer to ST7789VI datasheet for details

3.3 Reset Timing



VDD =5V, VSS=0V, T_{OP}=25°C

| Item | Symbol | MIN. | TYP. | MAX. | Unit |
|-----------------------|-----------------|------|------|------|------|
| Reset LOW pulse width | t _{RW} | 10 | - | - | µs |
| Reset time | T _{RT} | - | - | 170 | ms |

4. Functions

4.1 Display Commands

| Instruction | D/C | /WR | D17-8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | Hex | Function |
|---------------|-----|-----|-------|-------|-------|-------|--------|-------|-------|-------|-------|-------|---------------------|
| NOP | 0 | ↑ | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | (00h) | No operation |
| SWRESET | 0 | ↑ | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | (01h) | Software reset |
| RDDID | 0 | ↑ | - | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | (04h) | Read display ID |
| | 1 | 1 | - | - | - | - | - | - | - | - | - | | Dummy read |
| | 1 | 1 | - | ID17 | ID16 | ID15 | ID14 | ID13 | ID12 | ID11 | ID10 | | ID1 read |
| | 1 | 1 | - | ID27 | ID26 | ID25 | ID24 | ID23 | ID22 | ID21 | ID20 | | ID2 read |
| | 1 | 1 | - | ID37 | ID36 | ID35 | ID34 | ID33 | ID32 | ID31 | ID30 | | ID3 read |
| RDDST | 0 | ↑ | - | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | (09h) | Read display status |
| | 1 | 1 | - | - | - | - | - | - | - | - | - | | Dummy read |
| | 1 | 1 | - | BSTON | MY | MX | MV | ML | RGB | MH | ST24 | | - |
| | 1 | 1 | - | ST23 | IFPF2 | IFPF1 | IFPF0 | IDMON | PTLON | SLOUT | NORON | | - |
| | 1 | 1 | - | ST15 | ST14 | INVON | ST12 | ST11 | DISON | TEON | GCS2 | | - |
| | 1 | 1 | - | GCS1 | GCS0 | TEM | ST4 | ST3 | ST2 | ST1 | ST0 | | - |
| RDDPM | 0 | ↑ | - | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | (0Ah) | Read display power |
| | 1 | 1 | - | - | - | - | - | - | - | - | - | | Dummy read |
| | 1 | 1 | - | BSTON | IDMON | PTLON | SLPOUT | NORON | DISON | 0 | 0 | | |
| RDD MADCTL | 0 | ↑ | - | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | (0Bh) | Read display |
| | 1 | 1 | - | - | - | - | - | - | - | - | - | | Dummy read |
| | 1 | 1 | - | MY | MX | MV | ML | RGB | MH | 0 | 0 | | - |
| RDD COLMOD | 0 | ↑ | - | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | (0Ch) | Read display pixel |
| | 1 | 1 | - | - | - | - | - | - | - | - | - | | Dummy read |
| | 1 | 1 | - | 0 | D6 | D5 | D4 | 0 | D2 | D1 | D0 | | - |
| RDDIM | 0 | ↑ | - | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | (0Dh) | Read display image |
| | 1 | 1 | - | - | - | - | - | - | - | - | - | | Dummy read |
| | 1 | 1 | - | VSSON | 0 | INVON | 0 | 0 | GC2 | GC1 | GC0 | | - |
| RDDSM | 0 | ↑ | - | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | (0Eh) | Read display signal |
| | 1 | 1 | - | - | - | - | - | - | - | - | - | | Dummy read |

| Instruction | D/C | /WR | D17-8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | Hex | Function |
|-------------|-----|----------|----------|-------|-------|-------|-------|-------|-------|-------|-------|--------------------|-------------------------------------|
| | 1 | 1 | - | TEON | TEM | 0 | 0 | 0 | 0 | 0 | 0 | | - |
| RDDSDR | 0 | ↑ | - | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | (0Fh) | Read display self-diagnostic result |
| | 1 | 1 | - | - | - | - | - | - | - | - | - | | Dummy read |
| | 1 | 1 | - | D7 | D6 | 0 | 0 | 0 | 0 | 0 | 0 | | - |
| SLPIN | 0 | ↑ | - | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | (10h) | Sleep in |
| SLPOUT | 0 | ↑ | - | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | (11h) | Sleep out |
| PTLON | 0 | ↑ | - | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | (12h) | Partial mode on |
| NORON | 0 | ↑ | - | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | (13h) | Partial off (Normal) |
| INVOFF | 0 | ↑ | - | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | (20h) | Display inversion off |
| INVON | 0 | ↑ | - | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | (21h) | Display inversion on |
| GAMSET | 0 | ↑ | - | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | (26h) | Display inversion on |
| | 1 | ↑ | - | 0 | 0 | 0 | 0 | GC3 | GC2 | GC1 | GC0 | | |
| DISPOFF | 0 | ↑ | - | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | (28h) | Display off |
| DISPON | 0 | ↑ | - | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | (29h) | Display on |
| CASET | 0 | ↑ | - | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | (2Ah) | Column address set |
| | 1 | ↑ | - | XS15 | XS14 | XS13 | XS12 | XS11 | XS10 | XS9 | XS8 | | X address start: |
| | 1 | ↑ | | XS7 | XS6 | XS5 | XS4 | XS3 | XS2 | XS1 | XS0 | | $0 \leq XS \leq X$ |
| | 1 | ↑ | | XE15 | XE14 | XE13 | XE12 | XE11 | XE10 | XE9 | XE8 | | X address start: |
| 1 | ↑ | | XE7 | XE6 | XE5 | XE4 | XE3 | XE2 | XE1 | XE0 | | $S \leq XE \leq X$ | |
| RASET | 0 | ↑ | - | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | (2Bh) | Row address set |
| | 1 | ↑ | - | YS15 | YS14 | YS13 | YS12 | YS11 | YS10 | YS9 | YS8 | | Y address start: |
| | 1 | ↑ | | YS7 | YS6 | YS5 | YS4 | YS3 | YS2 | YS1 | YS0 | | $0 \leq YS \leq Y$ |
| | 1 | ↑ | | YE15 | YE14 | YE13 | YE12 | YE11 | YE10 | YE9 | YE8 | | Y address start: |
| 1 | ↑ | | YE7 | YE6 | YE5 | YE4 | YE3 | YE2 | YE1 | YE0 | | $S \leq YE \leq Y$ | |
| RAMWR | 0 | ↑ | - | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | (2Ch) | Memory write |
| | 1 | ↑ | D1[17:8] | D1[7] | D1[6] | D1[5] | D1[4] | D1[3] | D1[2] | D1[1] | D1[0] | | Write data |
| | 1 | ↑ | Dx[17:8] | Dx[7] | Dx[6] | Dx[5] | Dx[4] | Dx[3] | Dx[2] | Dx[1] | Dx[0] | | |
| 1 | ↑ | Dn[17:8] | Dn[7] | Dn[6] | Dn[5] | Dn[4] | Dn[3] | Dn[2] | Dn[1] | Dn[0] | | | |
| RAMRD | 0 | ↑ | - | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | (2Eh) | Memory read |

| Instruction | D/C | /WR | D17-8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | Hex | Function |
|-------------|-----|-----|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---------------------------------------|
| | 1 | 1 | - | - | - | - | - | - | - | - | - | | Dummy read |
| | 1 | 1 | D1[17:8] | D1[7] | D1[6] | D1[5] | D1[4] | D1[3] | D1[2] | D1[1] | D1[0] | | Read data |
| | 1 | 1 | Dx[17:8] | Dx[7] | Dx[6] | Dx[5] | Dx[4] | Dx[3] | Dx[2] | Dx[1] | Dx[0] | | |
| | 1 | 1 | Dn[17:8] | Dn[7] | Dn[6] | Dn[5] | Dn[4] | Dn[3] | Dn[2] | Dn[1] | Dn[0] | | |
| PTLAR | 0 | ↑ | - | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | (30h) | Partial start/end address set |
| | 1 | ↑ | - | PSL15 | PSL14 | PSL13 | PSL12 | PSL11 | PSL10 | PSL9 | PSL8 | | Partial start address: (0, 1, 2, ..P) |
| | 1 | ↑ | - | PSL7 | PSL6 | PSL5 | PSL4 | PSL3 | PSL2 | PSL1 | PSL0 | | |
| | 1 | ↑ | - | PEL15 | PEL14 | PEL13 | PEL12 | PEL11 | PEL10 | PEL9 | PEL8 | | Partial end address (0, 1, 2, 3, , P) |
| | 1 | ↑ | - | PEL7 | PEL6 | PEL5 | PEL4 | PEL3 | PEL2 | PEL1 | PEL0 | | |
| VSCRDEF | 0 | ↑ | - | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | (33h) | Vertical scrolling definition |
| | 1 | ↑ | - | TFA15 | TFA14 | TFA13 | TFA12 | TFA11 | TFA10 | TFA9 | TFA8 | | |
| | 1 | ↑ | - | TFA7 | TFA6 | TFA5 | TFA4 | TFA3 | TFA2 | TFA1 | TFA0 | | |
| | 1 | ↑ | - | VSA15 | VSA14 | VSA13 | VSA12 | VSA11 | VSA10 | VSA9 | VSA8 | | |
| | 1 | ↑ | - | VSA7 | VSA6 | VSA5 | VSA4 | VSA3 | VSA2 | VSA1 | VSA0 | | |
| | 1 | ↑ | - | BFA15 | BFA14 | BFA13 | BFA12 | BFA11 | BFA10 | BFA9 | BFA8 | | |
| | 1 | ↑ | - | BFA7 | BFA6 | BFA5 | BFA4 | BFA3 | BFA2 | BFA1 | BFA0 | | |
| TEOFF | 0 | ↑ | - | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | (34h) | Tearing effect line off |
| TEON | 0 | ↑ | - | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | (35h) | Tearing effect line on |
| | 1 | ↑ | - | - | - | - | - | - | - | - | TEM | | |
| MADCTL | 0 | ↑ | - | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | (36h) | Memory data access control |
| | 1 | ↑ | - | MY | MX | MV | ML | RGB | 0 | 0 | 0 | | - |
| VSCRSADD | 0 | ↑ | - | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | (37h) | Vertical scrolling start address |
| | 1 | ↑ | - | VSP15 | VSP14 | VSP13 | VSP12 | VSP11 | VSP10 | VSP9 | VSP8 | | |
| | 1 | ↑ | - | VSP7 | VSP6 | VSP5 | VSP4 | VSP3 | VSP2 | VSP1 | VSP0 | | |
| IDMOFF | 0 | ↑ | - | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | (38h) | Idle mode off |
| IDMON | 0 | ↑ | - | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | (39h) | Idle mode on |
| COLMOD | 0 | ↑ | - | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | (3Ah) | Interface pixel format |

| Instruction | D/C | /WR | D17-8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | Hex | Function |
|-------------|-----|-----|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----------------------------------|
| | 1 | ↑ | - | 0 | D6 | D5 | D4 | 0 | D2 | D1 | D0 | | Interface format |
| RAMWRC | 0 | ↑ | - | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | (3Ch) | Memory write continue |
| | 1 | ↑ | D1[17:8] | D1[7] | D1[6] | D1[5] | D1[4] | D1[3] | D1[2] | D1[1] | D1[0] | | Write data |
| | 1 | ↑ | Dx[17:8] | Dx[7] | Dx[6] | Dx[5] | Dx[4] | Dx[3] | Dx[2] | Dx[1] | Dx[0] | | |
| | 1 | ↑ | Dn[17:8] | Dn[7] | Dn[6] | Dn[5] | Dn[4] | Dn[3] | Dn[2] | Dn[1] | Dn[0] | | |
| RAMRDC | 0 | ↑ | - | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | (3Eh) | Memory read continue |
| | 1 | 1 | - | - | - | - | - | - | - | - | - | | Dummy Read |
| | 1 | 1 | D1[17:8] | D1[7] | D1[6] | D1[5] | D1[4] | D1[3] | D1[2] | D1[1] | D1[0] | | |
| | 1 | 1 | Dx[17:8] | Dx[7] | Dx[6] | Dx[5] | Dx[4] | Dx[3] | Dx[2] | Dx[1] | Dx[0] | | |
| | 1 | 1 | Dn[17:8] | Dn[7] | Dn[6] | Dn[5] | Dn[4] | Dn[3] | Dn[2] | Dn[1] | Dn[0] | | |
| TESCAN | 0 | ↑ | - | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | (44h) | Set tear scanline |
| | 1 | ↑ | - | N15 | N14 | N13 | N12 | N11 | N10 | N9 | N8 | | |
| | 1 | ↑ | - | N7 | N6 | N5 | N4 | N3 | N2 | N1 | N0 | | |
| RDTESCAN | 0 | ↑ | - | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | (45h) | Get scanline |
| | 1 | 1 | - | - | - | - | - | - | - | - | - | | Dummy Read |
| | 1 | 1 | - | - | - | - | - | - | - | N9 | N8 | | |
| | 1 | 1 | - | N7 | N6 | N5 | N4 | N3 | N2 | N1 | N0 | | |
| WRDISBV | 0 | ↑ | - | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | (51h) | Write display brightness |
| | 1 | ↑ | - | DBV7 | DBV6 | DBV5 | DBV4 | DBV3 | DBV2 | DBV1 | DBV0 | | |
| RDDISBV | 0 | ↑ | - | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | (52h) | Read display brightness value |
| | 1 | 1 | - | - | - | - | - | - | - | - | - | | Dummy read |
| | 1 | 1 | - | DBV7 | DBV6 | DBV5 | DBV4 | DBV3 | DBV2 | DBV1 | DBV0 | | |
| WRCTRLD | 0 | ↑ | - | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | (53h) | Write CTRL display |
| | 1 | ↑ | - | 0 | 0 | BCTRL | 0 | DD | BL | 0 | 0 | | |
| RDCTRLD | 0 | ↑ | - | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | (54h) | Read CTRL value display |
| | 1 | 1 | - | - | - | - | - | - | - | - | - | | Dummy read |
| | 1 | 1 | - | 0 | 0 | BCTRL | 0 | DD | BL | 0 | 0 | | |

| Instruction | D/C | /WR | D17-8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | Hex | Function |
|-------------|-----|-----|-------|--------|--------|------|------|------|------|------|------|-------|---|
| WRCACE | 0 | ↑ | - | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | (55h) | Write content adaptive brightness control and Color enhancemnet |
| | 1 | ↑ | - | CECTRL | 0 | CE1 | CE0 | 0 | 0 | C1 | C0 | | |
| RDCABC | 0 | ↑ | - | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | (56h) | Read content adaptive brightness control |
| | 1 | 1 | - | - | - | - | - | - | - | - | - | | Dummy read |
| | 1 | 1 | - | 0 | CECTRL | 0 | 0 | 0 | 0 | C1 | C0 | | |
| WRCABCMB | 0 | ↑ | - | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | (5Eh) | Write CABC minimum brightness |
| | 1 | ↑ | - | CMB7 | CMB6 | CMB5 | CMB4 | CMB3 | CMB2 | CMB1 | CMB0 | | |
| RDCABCMB | 0 | ↑ | - | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | (5Fh) | Read CABC minimum brightness |
| | 1 | 1 | - | - | - | - | - | - | - | - | - | | Dummy read |
| | 1 | 1 | - | CMB7 | CMB6 | CMB5 | CMB4 | CMB3 | CMB2 | CMB1 | CMB0 | | |
| RDID1 | 0 | ↑ | - | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | (Dah) | Read ID1 |
| | 1 | 1 | - | - | - | - | - | - | - | - | - | | Dummy read |
| | 1 | 1 | - | ID17 | ID16 | ID15 | ID14 | ID13 | ID12 | ID11 | ID10 | | Read parameter |
| RDID2 | 0 | ↑ | - | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | (DBh) | Read ID2 |
| | 1 | 1 | - | - | - | - | - | - | - | - | - | | Dummy read |
| | 1 | 1 | - | ID27 | ID26 | ID25 | ID24 | ID23 | ID22 | ID21 | ID20 | | Read parameter |
| RDID3 | 0 | ↑ | - | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | (DCh) | Read ID3 |
| | 1 | 1 | - | - | - | - | - | - | - | - | - | | Dummy read |
| | 1 | 1 | | ID37 | ID36 | ID35 | ID34 | ID33 | ID32 | ID31 | ID30 | | Read parameter |

Notes:

1. There will be no abnormal visible effects on the display when S/W or H/W Reset are applied.
2. Please refer to ST7789s datasheet for details

4.2 Power off the LCD Module

It recommends that enter Sleep Mode before power off the LCD module.

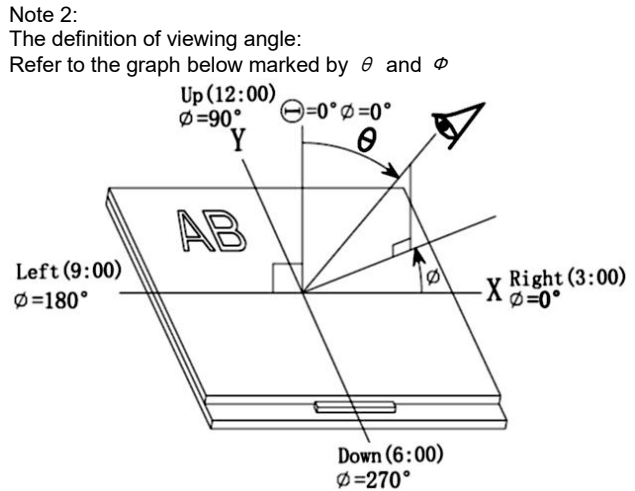
4.3 Refreshing The LCD Module

It recommends that the operating modes and display contents be refreshed periodically to prevent the effect of unexpected noise.

5. Optical Characteristics

| Item | Symbol | Condition | MIN. | TYP. | MAX. | UNIT | Note. |
|----------------------|------------------|--|------|------|------|-------------------|----------|
| Viewing angle | $\Phi=90^\circ$ | $(CR \geq 10)$ | 50 | 60 | - | degree | Note 1,6 |
| | $\Phi=270^\circ$ | | 50 | 60 | - | | |
| | $\Phi=180^\circ$ | | 40 | 50 | - | | |
| | $\Phi=0^\circ$ | | 50 | 60 | - | | |
| Contrast ratio | CR | $\Phi=0^\circ$ $\theta=0^\circ$ | 300 | 500 | - | - | Note 3 |
| Response Time | T_{on} | $\Phi=0^\circ$ $\theta=0^\circ$ | - | 30 | 50 | msec | Note 4 |
| | T_{off} | | | | | msec | |
| Chromaticity | Red | Backlight is on $\Phi=0^\circ$ $\theta=0^\circ$ | X | 0.55 | 0.60 | 0.65 | Note 1,5 |
| | | | Y | 0.30 | 0.35 | 0.40 | |
| | Green | | X | 0.27 | 0.32 | 0.37 | |
| | | | Y | 0.56 | 0.61 | 0.66 | |
| | Blue | | X | 0.09 | 0.14 | 0.19 | |
| | | | Y | 0.05 | 0.09 | 0.15 | |
| | White | | X | 0.26 | 0.29 | 0.32 | |
| | | | Y | 0.28 | 0.31 | 0.34 | |
| NTSC Ratio | S | | 45 | 65 | - | % | |
| Luminance | L | $\Phi=0^\circ$ | 200 | 250 | - | cd/m ² | Note 1,6 |
| Luminance uniformity | U | $\theta=0^\circ$ | 80 | - | - | % | Note 1,6 |

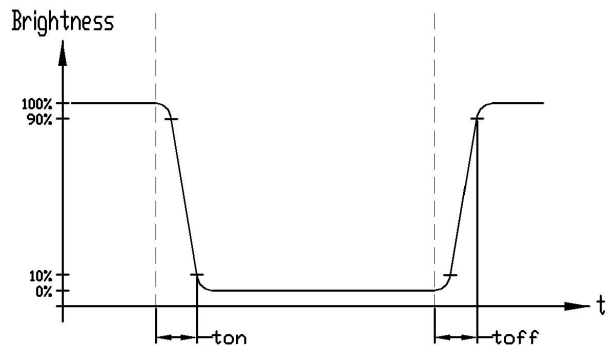
Note 1:
 The data are measured after LEDs are turned on for 5 minutes. LCM displays full white. The brightness is the average value of 9 measured spots. Measurement equipment PR-705
 Measuring condition:
 - Measuring surroundings: Dark room
 - Measuring temperature: Ta=25°C.
 - Adjust operating voltage to get optimum contrast at the center of the display.



Note 3:
 The definition of contrast ratio (Test LCM using PR-705):

$$\text{Contrast Ratio (CR)} = \frac{\text{Luminance When LCD is at "White" state}}{\text{Luminance When LCD is at "Black" state}}$$
 (Contrast Ratio is measured in optimum common electrode voltage)

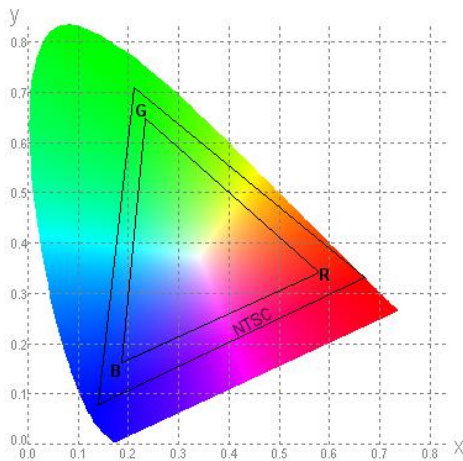
Note 4:
 Definition of Response time. (Test LCD using DMS501):
 The output signals of photo detector are measured when the input signals are changed from "black" to "white" (falling time) and from "white" to "black" (rising time), respectively. The response time is defined as the time interval between the 10% and 90% of amplitudes. Refer to figure as below.



Note 5:
 Definition of Color of CIE1931 Coordinate and NTSC Ratio.

Color gamut:

$$S = \frac{\text{Area of RGB triangle}}{\text{Area of NTSC triangle}} \times 100\%$$

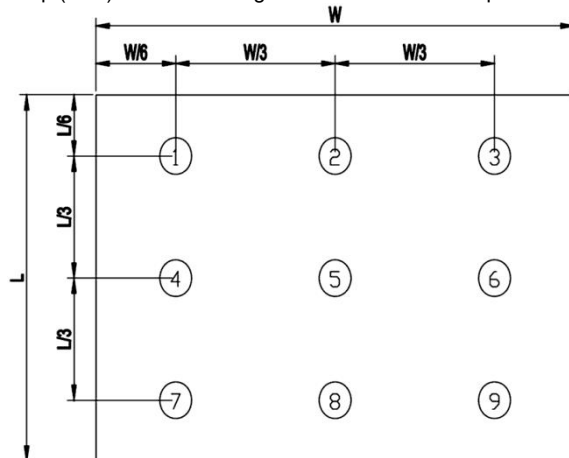


Note 6:
 The luminance uniformity is calculated by using following formula.

$$\Delta Bp = Bp (\text{Min.}) / Bp (\text{Max.}) \times 100 (\%)$$

$$Bp (\text{Max.}) = \text{Maximum brightness in 9 measured spots}$$

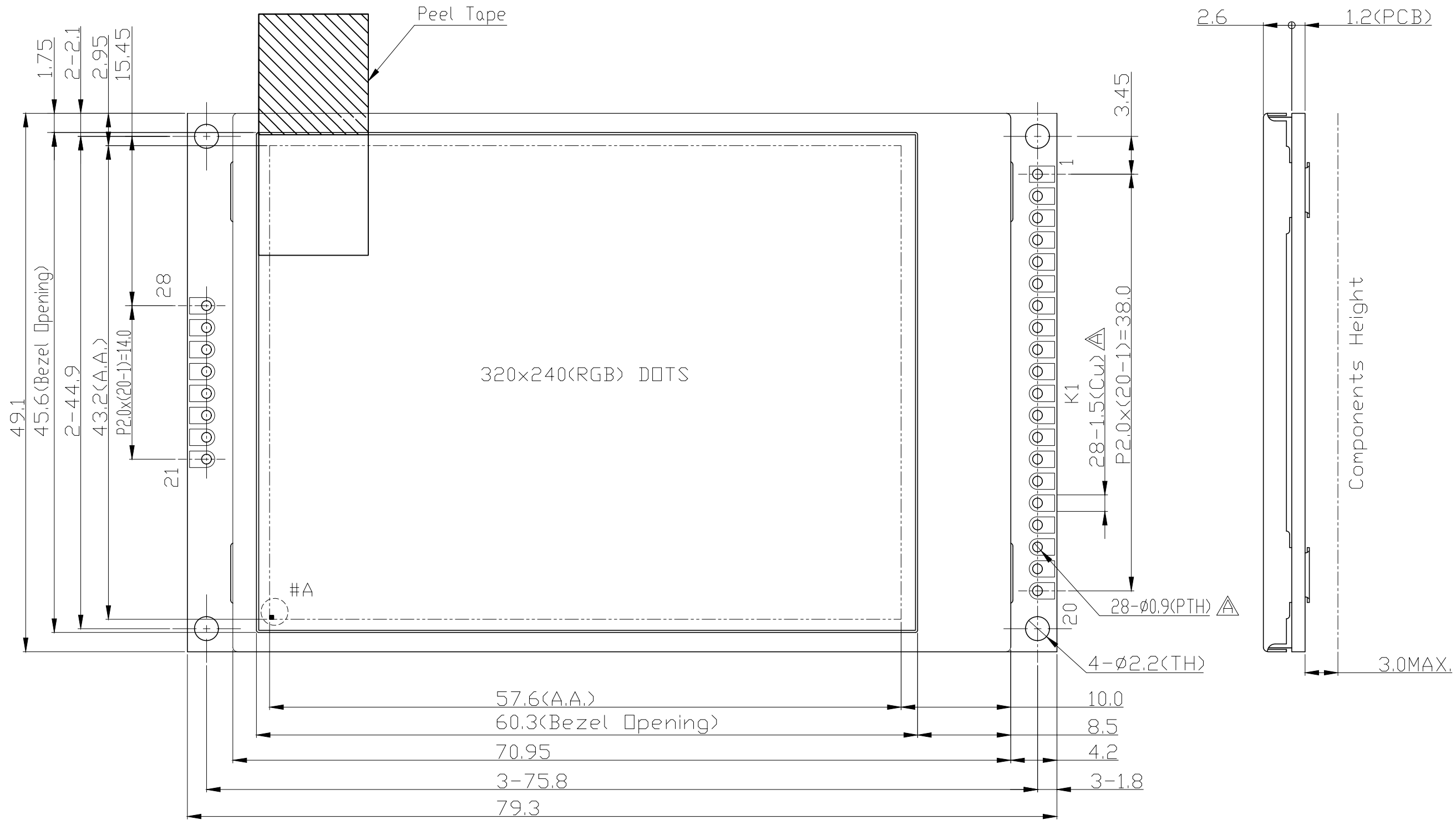
$$Bp (\text{Min.}) = \text{Minimum brightness in 9 measured spots.}$$



Note 7:
 Measured the luminance of white state at center point

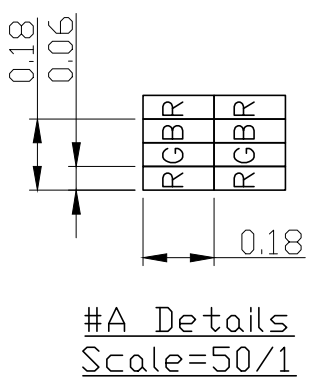
6. Design and Handling Precaution

1. The LCD panel is made by glass. Any mechanical shock (eg. dropping from high place) will damage the LCD module.
2. Do not add excessive force on the surface of the display, which may cause the Display color change abnormally.
3. The polarizer on the LCD is easily get scratched. If possible, do not remove the LCD protective film until the last step of installation.
4. Never attempt to disassemble or rework the LCD module.
5. Only Clean the LCD with Isopropyl Alcohol or Ethyl Alcohol. Other solvents (eg. water) may damage the LCD.
6. When mounting the LCD module, make sure that it is free from twisting, warping and distortion.
7. Ensure to provide enough space (with cushion) between case and LCD panel to prevent external force adding on it, or it may cause damage to the LCD or degrade the display result.
8. Only hold the LCD module by its side. Never hold LCD module by add force on the heat seal or TAB.
9. Never add force to component of the LCD module. It may cause invisible damage or degrade of the reliability.
10. LCD module could be easily damaged by static electricity. Be careful to maintain an optimum anti-static work environment to protect the LCD module.
11. When peeling off the protective film from LCD, static charge may cause abnormal display pattern. It is normal and will resume to normal in a short while.
12. Take care and prevent get hurt by the LCD panel sharp edge.
13. Never operate the LCD module exceed the absolute maximum ratings.
14. Keep the signal line as short as possible to prevent noisy signal applying to LCD module.
15. Never apply signal to the LCD module without power supply.
16. IC chip (eg. TAB or COG) is sensitive to the light. Strong lighting environment could possibly cause malfunction. Light sealing structure casing is recommend.
17. LCD module reliability may be reduced by temperature shock.
18. When storing the LCD module, avoid exposure to the direct sunlight, high humidity, high temperature or low temperature. They may damage or degrade the LCD module.



| K1 Terminal | |
|-------------|----------|
| No | Pin Name |
| 1 | VSS |
| 2 | VSS |
| 3 | BLDN |
| 4 | VDD |
| 5 | VDD |
| 6 | /RD |
| 7 | /WR |
| 8 | D/C |
| 9 | /CS |
| 10 | D0 |
| 11 | D1 |
| 12 | D2 |
| 13 | D3 |
| 14 | D4 |
| 15 | D5 |
| 16 | D6 |
| 17 | D7 |
| 18 | /RES |
| 19 | FMARK |
| 20 | NC |
| 21 | NC |
| 22 | NC |
| 23 | NC |
| 24 | NC |
| 25 | NC |
| 26 | NC |
| 27 | NC |
| 28 | NC |

- Note:
- *1. LCD Display Type : TFT, Transmissive
 - *2. Pixel Arrangement : RGB-STRIPE
 - *3. Signal Interface : MCU 8bit
 - *4. Color Depth : 65k Colors
 - *5. Operating Voltage : 5.0V
 - *6. Logic Voltage : 3.0V
 - *7. Backlight : White LEDs
 - *8. Operating Temperature : -20°C~70°C
 - *9. Storage Temperature : -30°C~80°C



| | | |
|--|-------------------|-----------------------|
| C | | |
| B | | |
| A | Typing Correction | Luo Lin 2020-08-13 |
| Rev | Note | Date |
| Dwg Title LMT028DHHFWL-NBN Outline Dwg | | |
| Dwg No. | MK-006305a-1-1 | Date 2018-03-14 |
| Scale | Tol. ±0.5 | Unit mm Paper Size A3 |
| Approved | Checked | Drawn Luo Lin |