

**Product Specification**

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# NHD-2.4-240320AF-CTXP-T

## TFT Liquid Crystal Display

|                |                                     |
|----------------|-------------------------------------|
| <b>NHD-</b>    | Newhaven Display                    |
| <b>2.4-</b>    | Diagonal                            |
| <b>240320-</b> | 240xRGBx320 Pixels                  |
| <b>AF-</b>     | Model                               |
| <b>C-</b>      | Built-in Controller                 |
| <b>T-</b>      | Low Brightness, White LED Backlight |
| <b>X-</b>      | TFT                                 |
| <b>P-</b>      | IPS, Wide Temperature               |
| <b>T-</b>      | 4-Wire Resistive Touch Panel        |

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## Additional Resources

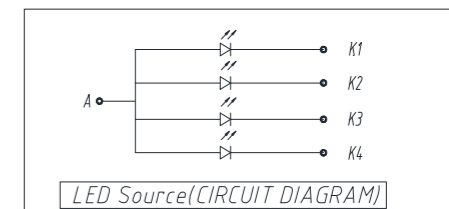
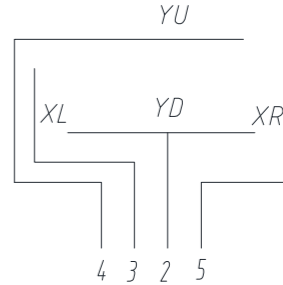
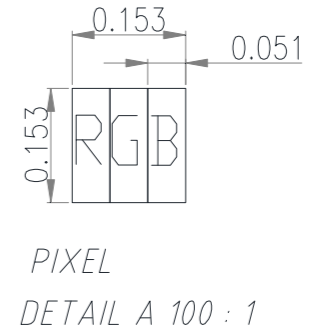
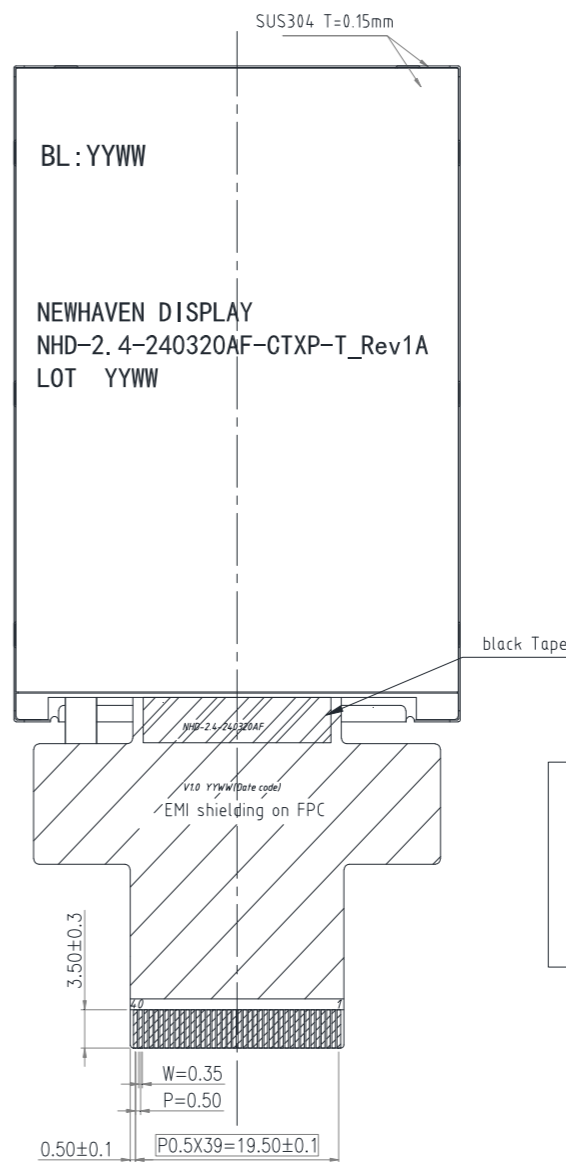
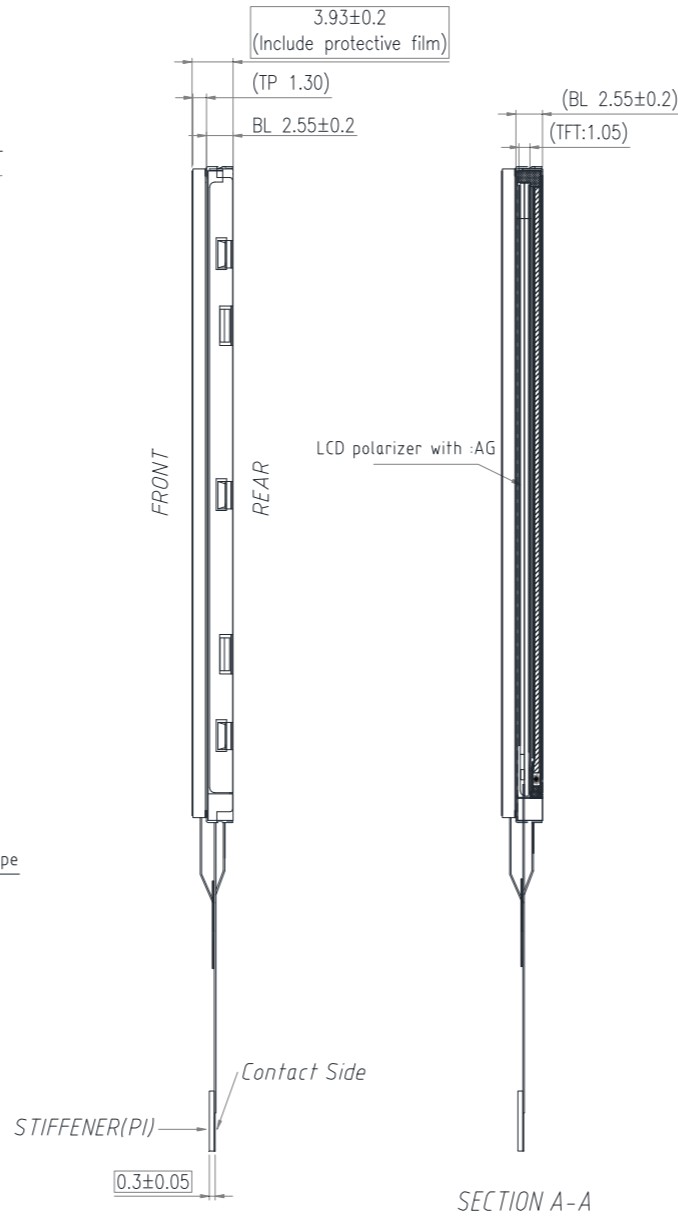
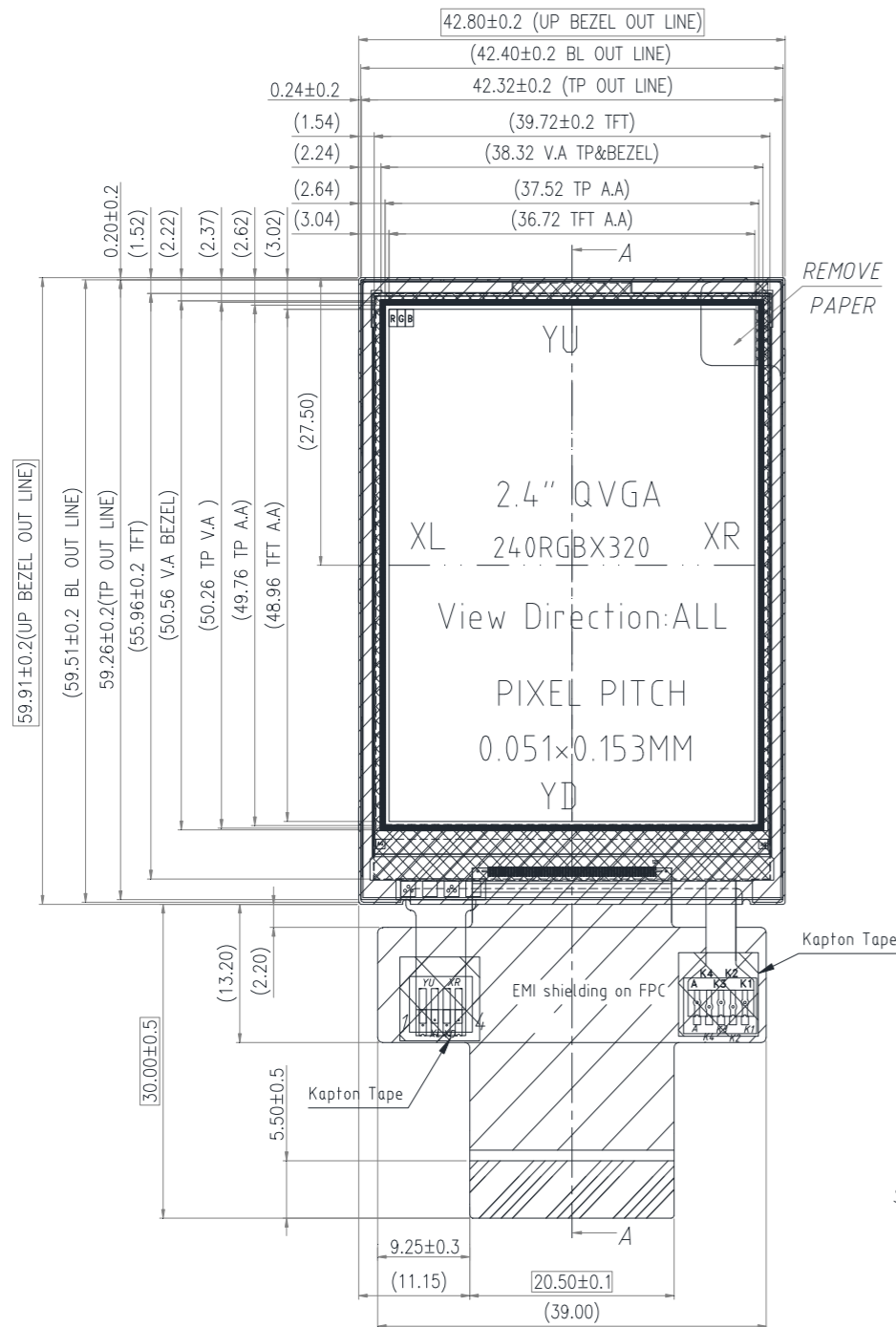
- **Support Forum:** <https://support.newhavendisplay.com/hc/en-us/community/topics>
- **GitHub:** <https://github.com/newhavendisplay>
- **Example Code:** <https://support.newhavendisplay.com/hc/en-us/categories/4409527834135-Example-Code/>
- **Knowledge Center:** [https://www.newhavendisplay.com/knowledge\\_center.html](https://www.newhavendisplay.com/knowledge_center.html)
- **Quality Center:** [https://www.newhavendisplay.com/quality\\_center.html](https://www.newhavendisplay.com/quality_center.html)
- **Precautions for using LCDs/LCMs:** <https://www.newhavendisplay.com/specs/precautions.pdf>
- **Warranty / Terms & Conditions:** <https://www.newhavendisplay.com/terms.html>



## Document Revision History

| Revision | Date       | Description     | Changed By |
|----------|------------|-----------------|------------|
| -        | 09/18/2023 | Initial Release | KL         |

# Mechanical Drawing



| No. | PIN NAME |
|-----|----------|
| 1   | GND      |
| 2   | YD       |
| 3   | XL       |
| 4   | YU       |
| 5   | XR       |
| 6   | SDO      |
| 7   | VDD      |
| 8   | VDDI     |
| 9   | SDA      |
| 10  | CSX      |
| 11  | DCX      |
| 12  | WRX      |
| 13  | RDX      |
| 14  | DB0      |
| 15  | DB1      |
| 16  | DB2      |
| 17  | DB3      |
| 18  | DB4      |
| 19  | DB5      |
| 20  | DB6      |
| 21  | DB7      |
| 22  | DB8      |
| 23  | DB9      |
| 24  | DB10     |
| 25  | DB11     |
| 26  | DB12     |
| 27  | DB13     |
| 28  | DB14     |
| 29  | DB15     |
| 30  | RESX     |
| 31  | IM0      |
| 32  | IM2      |
| 33  | GND      |
| 34  | LED-K1   |
| 35  | LED-K2   |
| 36  | LED-K3   |
| 37  | LED-K4   |
| 38  | LED-A    |
| 39  | GND      |
| 40  | TE       |

Product Description: 2.4" 240x320 IPS TFT w/ Resistive Touch

1. Driver IC: ST7789VI
2. Interface: 8/16-bit 8080-II Parallel RGB TFT, 3-line SPI RTP
3. Power Requirement: 3.3V TFT, 3.1V/80mA Backlight
4. Optical Features: Normally Black, Transmissive, Anti-Glare, 280cd/m<sup>2</sup>
5. Recommended FFC Connector:
  - TFT: 40 pin 0.5mm pitch; Ex. Molex 54132-4062
  - RTP: 4pin 1.0mm pitch
6. EMI Shielded FPC

|   |  |  |
|---|--|--|
| <b>Standard Tolerance:</b><br>(Unless otherwise specified)<br><br>Linear: ±0.3mm  |  |  |
|   | Drawing/Part Number:<br><b>NHD-2.4-240320AF-CTXP-T</b> | Revision:<br><b>1A</b>                             |
| <b>Unless otherwise specified:</b><br>• Dimensions are in Millimeters<br>• Third Angle Projection   | Drawn By: K. Lewis<br>Drawn Date: 08/02/2023           | Approved By: K. Lewis<br>Approved Date: 08/02/2023 |
| This drawing is solely the property of Newhaven Display International, Inc. The information it contains is not to be disclosed, reproduced or copied in whole or part without written approval from Newhaven Display. |  |  |

## Pin Description

| Pin No. | Symbol | External Connection | Function Description   |
|---------|--------|---------------------|--|
| 1       | GND    | Power Supply        | Ground   |
| 2       | YD     | Touch Controller    | Touch Panel - Down   |
| 3       | XL     | Touch Controller    | Touch Panel - Left   |
| 4       | YU     | Touch Controller    | Touch Panel - Up   |
| 5       | XR     | Touch Controller    | Touch Panel - Right  |
| 6       | SDO    | MPU                 | Serial Data output   |
| 7       | VDD    | Power Supply        | Supply Voltage for LCD (3.3V)  |
| 8       | VDDI   | Power Supply        | Supply Voltage for Logic   |
| 9       | SDA    | MPU                 | Serial Data Input  |
| 10      | CSX    | MPU                 | Active LOW Chip Select signal  |
| 11      | DCX    | MPU                 | <b>Parallel Interface:</b><br>Data / Command selection: '1' = Data; '0' = Command<br><b>Serial Interface:</b><br>Serial Clock Signal |
| 12      | WRX    | MPU                 | Active LOW Write signal  |
| 13      | RDX    | MPU                 | Active LOW Read signal   |
| 14      | DB0    | MPU                 | Bi-directional data bus<br><br>8-bit: use DB8-DB15<br>16-bit: use DB0-DB15   |
| 15      | DB1    | MPU                 |  |
| 16      | DB2    | MPU                 |  |
| 17      | DB3    | MPU                 |  |
| 18      | DB4    | MPU                 |  |
| 19      | DB5    | MPU                 |  |
| 20      | DB6    | MPU                 |  |
| 21      | DB7    | MPU                 |  |
| 22      | DB8    | MPU                 |  |
| 23      | DB9    | MPU                 |  |
| 24      | DB10   | MPU                 |  |
| 25      | DB11   | MPU                 |  |
| 26      | DB12   | MPU                 |  |
| 27      | DB13   | MPU                 |  |
| 28      | DB14   | MPU                 |  |
| 29      | DB15   | MPU                 |  |
| 30      | RESX   | MPU                 | Active LOW Reset signal  |
| 31      | IM0    | MPU                 | Interface Mode Select  |
| 32      | IM2    | MPU                 | Interface Mode Select  |
| 33      | GND    | Power Supply        | Ground   |
| 34      | LED-K1 | Power Supply        | Backlight Cathode (Ground)   |
| 35      | LED-K2 | Power Supply        |  |
| 36      | LED-K3 | Power Supply        |  |
| 37      | LED-K4 | Power Supply        |  |
| 38      | LED-A  | Power Supply        | Backlight Anode (3.1V/80mA)  |
| 39      | GND    | Power Supply        | Ground   |
| 40      | TE     | MPU                 | Tearing Effect Output  |

Recommended LCD connector: 40-pin, 0.5mm pitch FFC connector

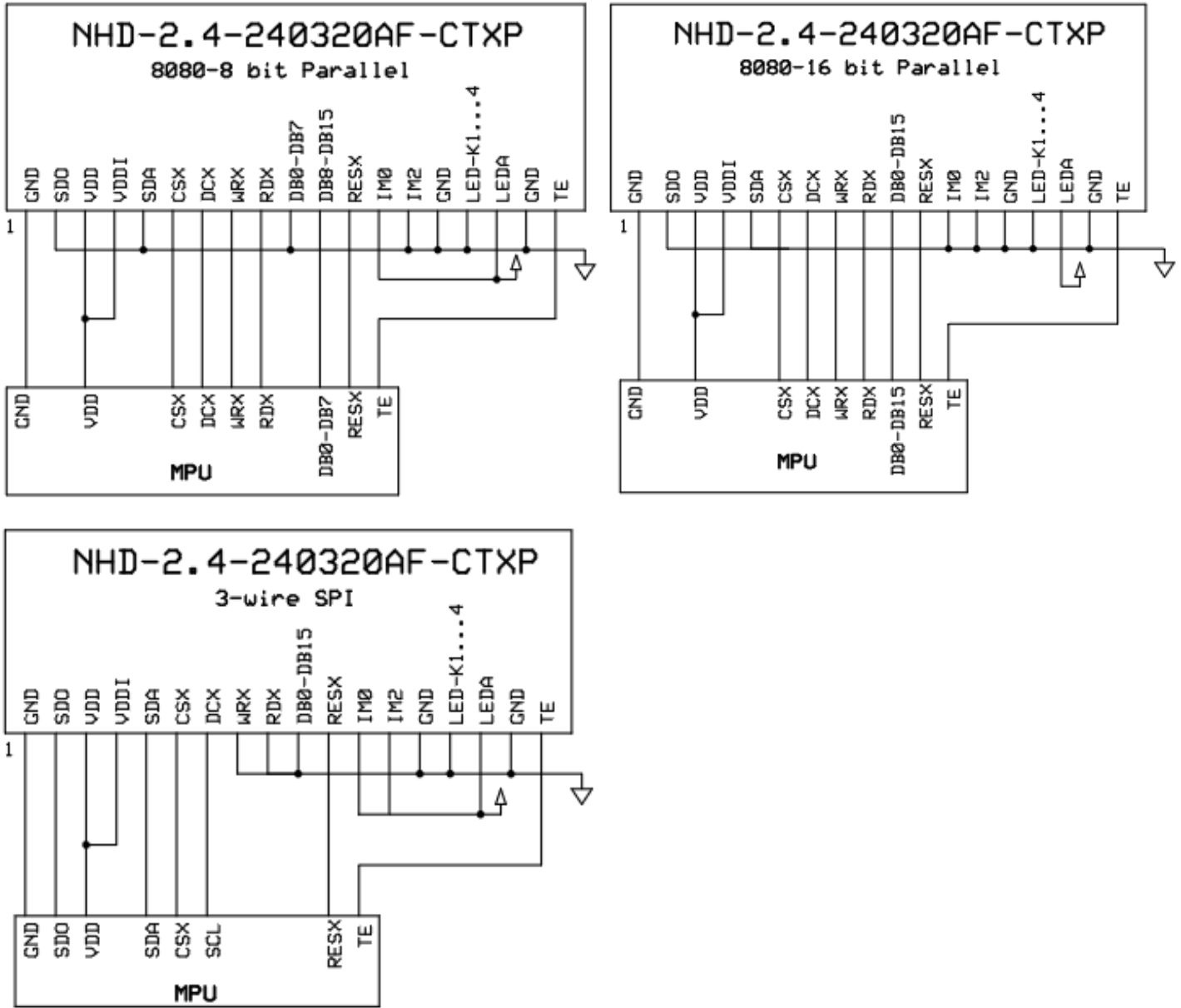
Molex P/N: 54132-4062 or similar

## Interface Selection

| Pin Name | 8-bit 8080-II Parallel | 16-bit 8080-II Parallel | 3-wire SPI |
|----------|------------------------|-------------------------|------------|
| IM0      | 1                      | 0                       | 1          |
| IM2      | 0                      | 0                       | 1          |



## Wiring Diagram



## Electrical Characteristics

| Item                        | Symbol            | Condition   | Min.                   | Typ. | Max.                   | Unit |
|-----------------------------|-------------------|---|------------------------|------|------------------------|------|
| Operating Temperature Range | T <sub>OP</sub>   | Absolute Max                                      | -20                    | -    | +70                    | °C   |
| Storage Temperature Range   | T <sub>ST</sub>   | Absolute Max                                      | -30                    | -    | +80                    | °C   |
| Supply Voltage for LCD      | V <sub>DD</sub>   | -   | 2.4                    | 3.3  | 3.6                    | V    |
| Supply Voltage for Logic    | IOV <sub>DD</sub> | -   | 1.65                   | 1.8  | 3.6                    | V    |
| Supply Current              | I <sub>DD</sub>   | V <sub>DD</sub> = 3.3V                            | 4                      | 6    | 12                     | mA   |
| "H" Level input             | V <sub>IH</sub>   | -   | 0.7 * V <sub>DDI</sub> | -    | V <sub>DDI</sub>       | V    |
| "L" Level input             | V <sub>IL</sub>   | -   | V <sub>SS</sub>        | -    | 0.3 * V <sub>DDI</sub> | V    |
| "H" Level output            | V <sub>OH</sub>   | -   | 0.8 * V <sub>DDI</sub> | -    | V <sub>DDI</sub>       | V    |
| "L" Level output            | V <sub>OL</sub>   | -   | V <sub>SS</sub>        | -    | 0.2 * V <sub>DDI</sub> | V    |
| Backlight Supply Current    | I <sub>LED</sub>  | -   | 40                     | 80   | 100                    | mA   |
| Backlight Supply Voltage    | V <sub>LED</sub>  | I <sub>LED</sub> = 80mA                           | 2.7                    | 3.1  | 3.5                    | V    |
| Backlight Lifetime*         | -                 | I <sub>LED</sub> = 80mA<br>T <sub>OP</sub> = 25°C | 30,000                 | -    | -                      | Hrs. |

\*Backlight Lifetime is rated as Hours until **half-brightness**, under normal operating conditions. The LED of the backlight is driven by current drain; drive voltage is for reference only. Drive voltage must be selected to ensure backlight current drain is below MAX level stated.

## Optical Characteristics

| Item                   |        | Symbol                          | Condition               | Min.  | Typ.  | Max.  | Unit              |
|------------------------|--------|---------------------------------|-------------------------|-------|-------|-------|-------------------|
| Optimal Viewing Angles | Top    | φY+                             | CR ≥ 10                 | 70    | 80    | -     | °                 |
|                        | Bottom | φY-                             |                         | 70    | 80    | -     | °                 |
|                        | Left   | θX-                             |                         | 70    | 80    | -     | °                 |
|                        | Right  | θX-                             |                         | 70    | 80    | -     | °                 |
| Contrast Ratio         |        | CR                              | -                       | 1000  | 1500  | -     | -                 |
| Luminance              |        | L <sub>V</sub>                  | I <sub>LED</sub> = 80mA | 200   | 280   | 390   | cd/m <sup>2</sup> |
| Response Time          |        | T <sub>R</sub> + T <sub>F</sub> | T <sub>OP</sub> = 25°C  | -     | 35    | 45    | ms                |
| Chromaticity           | Red    | X <sub>R</sub>                  | -                       | 0.611 | 0.641 | 0.671 | -                 |
|                        |        | Y <sub>R</sub>                  | -                       | 0.306 | 0.336 | 0.366 | -                 |
|                        | Green  | X <sub>G</sub>                  | -                       | 0.307 | 0.337 | 0.367 | -                 |
|                        |        | Y <sub>G</sub>                  | -                       | 0.563 | 0.593 | 0.623 | -                 |
|                        | Blue   | X <sub>B</sub>                  | -                       | 0.113 | 0.143 | 0.173 | -                 |
|                        |        | Y <sub>B</sub>                  | -                       | 0.038 | 0.068 | 0.098 | -                 |
|                        | White  | X <sub>W</sub>                  | -                       | 0.276 | 0.306 | 0.336 | -                 |
|                        |        | Y <sub>W</sub>                  | -                       | 0.295 | 0.325 | 0.355 | -                 |

## Touch Panel Characteristic

| Item                        | Min.      | Typ. | Max. | Unit       |
|-----------------------------|-----------|------|------|------------|
| Linearity                   | -         | -    | 1.5  | %          |
| Circuit Resistance – X-Axis | 200       | -    | 600  | $\Omega$   |
| Circuit Resistance – Y-Axis | 250       | -    | 900  | $\Omega$   |
| Insulation Resistance       | 20        | -    | -    | M $\Omega$ |
| Operating Voltage           | -         | -    | 5    | V          |
| Chattering                  | -         | -    | 15   | ms         |
| Activation Force            | 100       | -    | -    | gf         |
| Pen Writing Durability      | 100,000   | -    | -    | Characters |
| Pitting Durability          | 1,000,000 | -    | -    | Touches    |
| Surface Hardness            | 3         | -    | -    | H          |

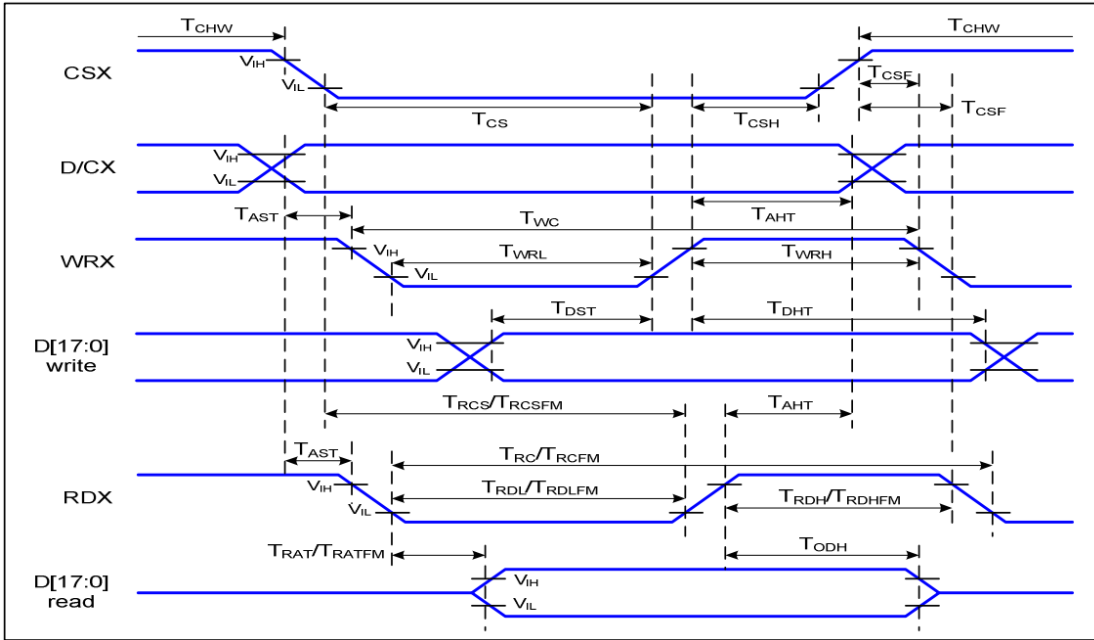
## Controller Information

Built-in ST7789VI Controller: <https://support.newhavendisplay.com/hc/en-us/articles/10814990300823-ST7789VI>



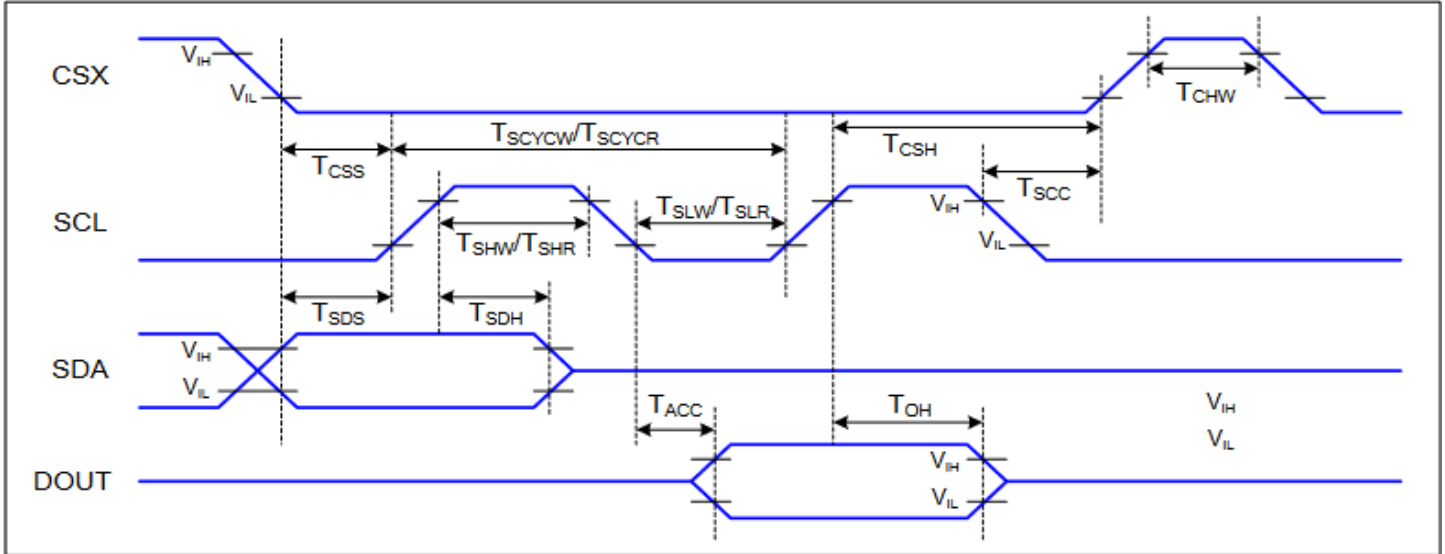
# Timing Characteristics for TFT

## Parallel 8/16-bit Interface Timing Characteristics



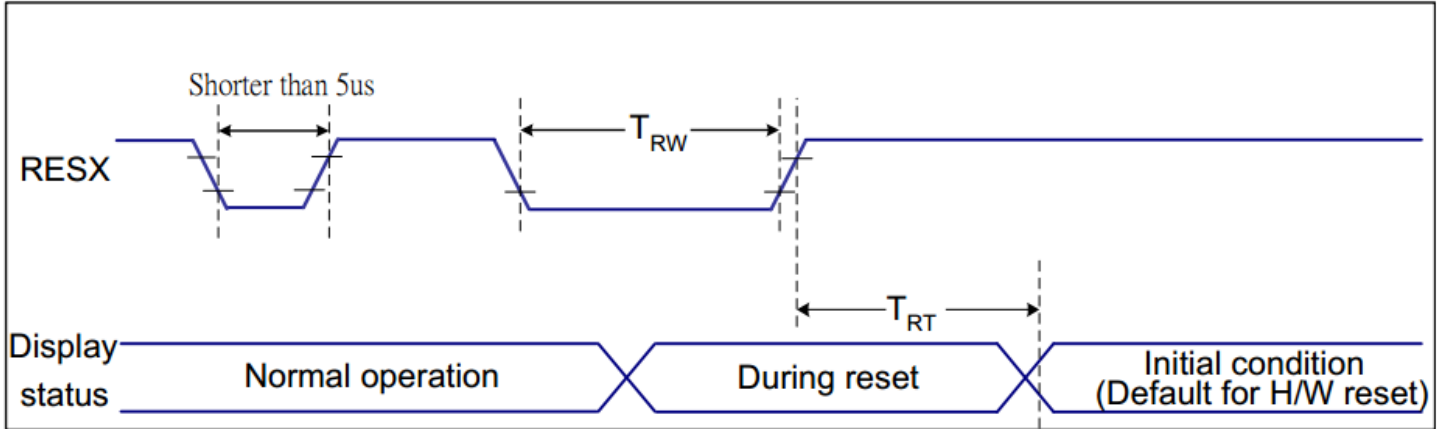
| Signal   | Symbol      | Parameter                          | Min | Max | Unit | Description                 |
|----------|-------------|------------------------------------|-----|-----|------|-----------------------------|
| D/CX     | $T_{AST}$   | Address setup time                 | 0   |     | 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                 |
|          | $T_{DHT}$   | 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   |                             |

### 3-line Serial interface Timing Characteristics



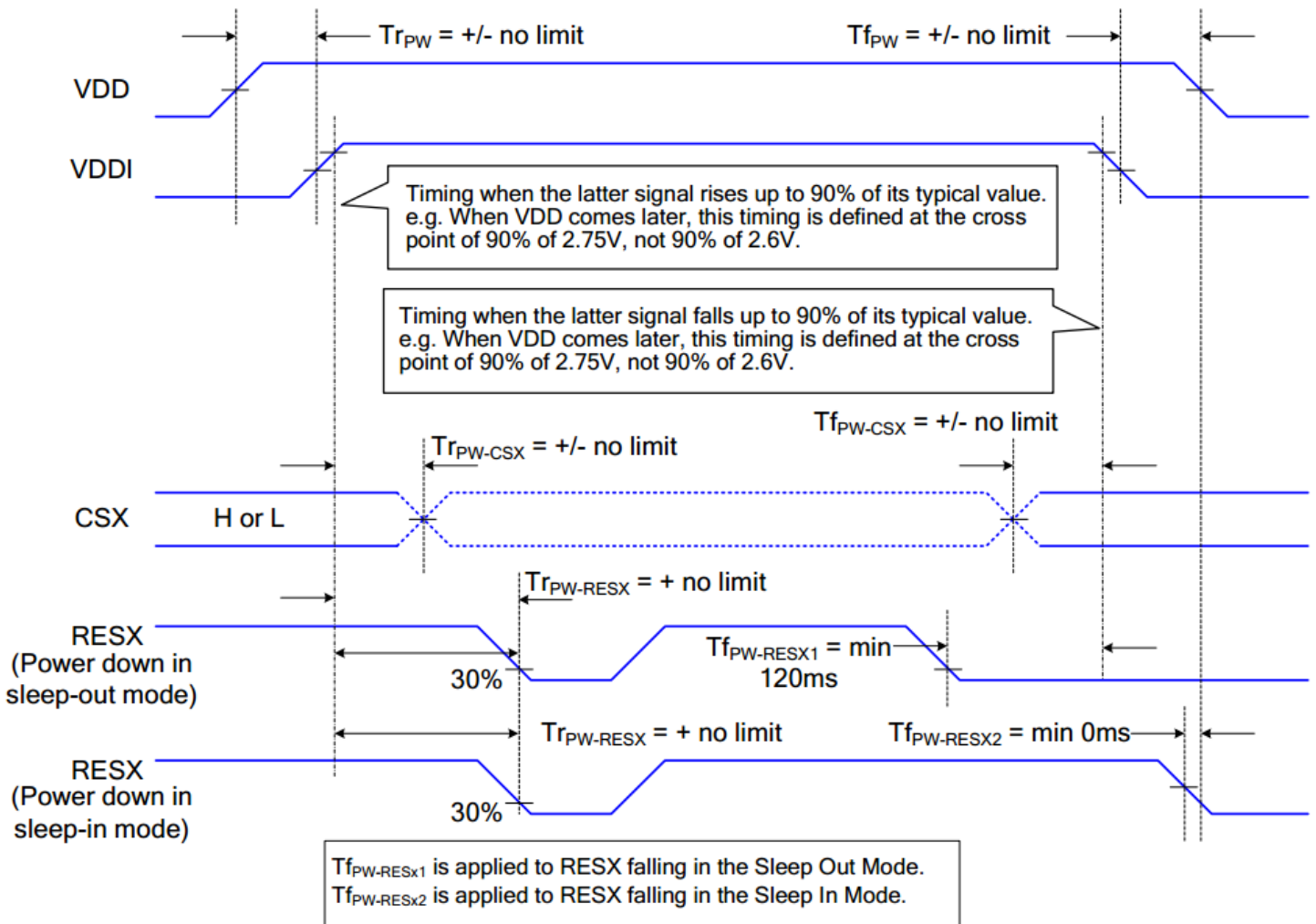
| Signal       | Symbol      | Parameter                      | Min | Max | Unit | Description         |
|--------------|-------------|--------------------------------|-----|-----|------|---------------------|
| CSX          | $T_{CSS}$   | Chip select setup time (write) | 15  |     | ns   |                     |
|              | $T_{CSH}$   | Chip select hold time (write)  | 15  |     | ns   |                     |
|              | $T_{CSS}$   | Chip select setup time (read)  | 60  |     | ns   |                     |
|              | $T_{SCC}$   | Chip select hold time (read)   | 65  |     | ns   |                     |
|              | $T_{CHW}$   | Chip select "H" pulse width    | 40  |     | ns   |                     |
| SCL          | $T_{SCYCW}$ | Serial clock cycle (Write)     | 16  |     | ns   |                     |
|              | $T_{SHW}$   | SCL "H" pulse width (Write)    | 7   |     | ns   |                     |
|              | $T_{SLW}$   | SCL "L" pulse width (Write)    | 7   |     | ns   |                     |
|              | $T_{SCYCR}$ | Serial clock cycle (Read)      | 150 |     | ns   |                     |
|              | $T_{SHR}$   | SCL "H" pulse width (Read)     | 60  |     | ns   |                     |
|              | $T_{SLR}$   | SCL "L" pulse width (Read)     | 60  |     | ns   |                     |
| SDA<br>(DIN) | $T_{SDS}$   | Data setup time                | 7   |     | ns   |                     |
|              | $T_{SDH}$   | Data hold time                 | 7   |     | ns   |                     |
| DOUT         | $T_{ACC}$   | Access time                    | 10  | 50  | ns   | For maximum CL=30pF |
|              | $T_{OH}$    | Output disable time            | 15  | 50  | ns   | For minimum CL=8pF  |

## Reset Timing



| 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   |

## Power ON/OFF Sequence



## Example Initialization Code

```

void Command_out(unsigned char c) //Function used for sending commands to TFT
{
  PORTA &= ~(1 << PORTA3); // Set DCX pin to LOW
  PORTL=c; // Assigning the Command Byte 'c' to PortL
  PORTA &= ~(1 << PORTA7); // Set WRX pin to LOW
  PORTA |= (1 << PORTA7); // Set WRX pin to HIGH
}

void data_out(unsigned char d) //Function used for sending data to TFT
{
  PORTA |= (1 << PORTA3); // Set DCX pin to HIGH
  PORTL=d; // Assigning the Data Byte 'd' to PortL
  PORTA &= ~(1 << PORTA7); // Set WRX pin to LOW
  PORTA |= (1 << PORTA7); // Set WRX pin to HIGH
}

void TFT_init(){

  digitalWrite(RESEX, LOW);
  delay(250);
  digitalWrite(RESEX, HIGH);
  delay(250);

  Command_out(0x28); //display off
  Command_out(0x11); //exit SLEEP mode
  delay(100);

  Command_out(0x36); //MADCTL: memory data access control
  data_out(0x88);

  Command_out(0x3A); //COLMOD: Interface Pixel format *** 65K-colors in 16bit/pixel (5-
6-5) format when using 16-bit interface to allow 1-byte per pixel
  data_out(0x55);

  Command_out(0xB2); //PORCTRK: Porch setting
  data_out(0x0C);
  data_out(0x0C);
  data_out(0x00);
  data_out(0x33);
  data_out(0x33);

  Command_out(0xB7); //GCTRL: Gate Control
  data_out(0x35);

  Command_out(0xBB); //VCOMS: VCOM setting
  data_out(0x2B);

  Command_out(0xC0); //LCMCTRL: LCM Control
  data_out(0x2C);

  Command_out(0xC2); //VDVVRHEN: VDV and VRH Command Enable
  data_out(0x01);
  data_out(0xFF);

  Command_out(0xC3); //VRHS: VRH Set
  data_out(0x11);

```

```
Command_out(0xC4); //VDVS: VDV Set
data_out(0x20);

Command_out(0xC6); //FRCTRL2: Frame Rate control in normal mode
data_out(0x0F);

Command_out(0xD0); //PWCTRL1: Power Control 1
data_out(0xA4);
data_out(0xA1);

Command_out(0xE0); //PVGAMCTRL: Positive Voltage Gamma control
data_out(0xD0);
data_out(0x00);
data_out(0x05);
data_out(0x0E);
data_out(0x15);
data_out(0x0D);
data_out(0x37);
data_out(0x43);
data_out(0x47);
data_out(0x09);
data_out(0x15);
data_out(0x12);
data_out(0x16);
data_out(0x19);

Command_out(0xE1); //NVGAMCTRL: Negative Voltage Gamma control
data_out(0xD0);
data_out(0x00);
data_out(0x05);
data_out(0x0D);
data_out(0x0C);
data_out(0x06);
data_out(0x2D);
data_out(0x44);
data_out(0x40);
data_out(0x0E);
data_out(0x1C);
data_out(0x18);
data_out(0x16);
data_out(0x19);

Command_out(0x2A); //X address set
data_out(0x00);
data_out(0x00);
data_out(0x00);
data_out(0xEF);

Command_out(0x2B); //Y address set
data_out(0x00);
data_out(0x00);
data_out(0x01);
data_out(0x3F);
delay(10);
Command_out(0x21); //Color inversion for IPS
Command_out(0x29); //display ON
delay(10);
}
```

## Quality Information

| Test Item                             | Content of Test   | Test Condition  | Note |
|---------------------------------------|---|---|------|
| High Temperature Storage              | Endurance test applying the high storage temperature for a long time.   | +80°C, 240hrs   | 2    |
| Low Temperature Storage               | Endurance test applying the low storage temperature for a long time.  | -30°C, 240hrs   | 1,2  |
| High Temperature Operation            | Endurance test applying the electric stress (voltage & current) and the high thermal stress for a long time.                    | +70°C, 120hrs   | 2    |
| Low Temperature Operation             | Endurance test applying the electric stress (voltage & current) and the low thermal stress for a long time.                     | -20°C, 120hrs   | 1,2  |
| High Temperature / Humidity Operation | Endurance test applying the electric stress (voltage & current) and the high thermal with high humidity stress for a long time. | +60°C, 90% RH, 240hrs   | 1,2  |
| Thermal Shock resistance              | Endurance test applying the electric stress (voltage & current) during a cycle of low and high thermal stress.                  | -30°C 30min -> 25°C 5min -> 80°C 30min = 1 cycle.<br>For 100 cycles |      |
| Vibration test                        | Endurance test applying vibration to simulate transportation and use.   | 10Hz-55Hz, 1.5mm amplitude.<br>10min in each of 3 directions X,Y,Z  | 3    |
| Static electricity test               | Endurance test applying electric static discharge.  | Air discharge: ±8kV 10 Times<br>Contact discharge: ±4kV 10 Times    |      |

**Note 1:** No condensation to be observed.

**Note 2:** Conducted after 4 hours of storage at 25°C, 0%RH.

**Note 3:** Test performed on product itself, not inside a container.