

# 4inch e-Paper User Manual

## Revision History

| Version | Content      | Date       | Page |
|---------|--------------|------------|------|
| 1.0     | New creation | 2024/09/05 | All  |
|         |              |            |      |
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## Contents

|                                                                           |    |
|---------------------------------------------------------------------------|----|
| 1. OVERVIEW .....                                                         | 1  |
| 2. FEATURES .....                                                         | 2  |
| 3. MECHANICAL SPECIFICATION .....                                         | 3  |
| 4. MECHANICAL DRAWING OF EPD MODULE .....                                 | 4  |
| 5. INPUT/OUTPUT INTERFACE .....                                           | 5  |
| 5.1 Connector Type: Golden Finger for ZIF Type FH34rj-50s-0.5sh(50) ..... | 5  |
| 6. ELECTRICAL CHARACTERISTICS .....                                       | 8  |
| 6.1 Absolute Maximum Rating .....                                         | 8  |
| 6.2 Panel DC Characteristics .....                                        | 9  |
| 7. POWER SEQUENCE .....                                                   | 12 |
| 7.1 Power on Sequence Display .....                                       | 12 |
| 7.2 Power off Sequence Display .....                                      | 13 |
| 8. OPTICAL CHARACTERISTICS .....                                          | 14 |
| 8.1 Specification .....                                                   | 14 |
| 8.2 Definition of Contrast Ratio .....                                    | 15 |
| 8.3 Reflection Ratio .....                                                | 16 |
| 8.3 Definition of Color Performance & Saturation Ratio .....              | 16 |
| 9. REFERENCE CIRCUIT .....                                                | 17 |
| 10. HANDLING, SAFETY, AND ENVIRONMENT REQUIREMENTS .....                  | 18 |
| 11. RELIABILITY TEST .....                                                | 20 |
| 12. BLOCK DIAGRAM .....                                                   | 21 |
| 13. BORDER DEFINITION .....                                               | 22 |
| 14. PACKAGE .....                                                         | 23 |

## 1. OVERVIEW

The 4-inch e-Paper is a reflective electrophoretic E Ink® Spectra™ 6 Display module based on glass active matrix TFT substrate. It has 4.0" active area with 400(H) x 600(V) pixels. The panel can display vivid color that include black, white, yellow, red, green and blue depending on the associated lookup table used. The display is capable to display images with full colors driven by the all-in-one display controller and the associated waveform file.



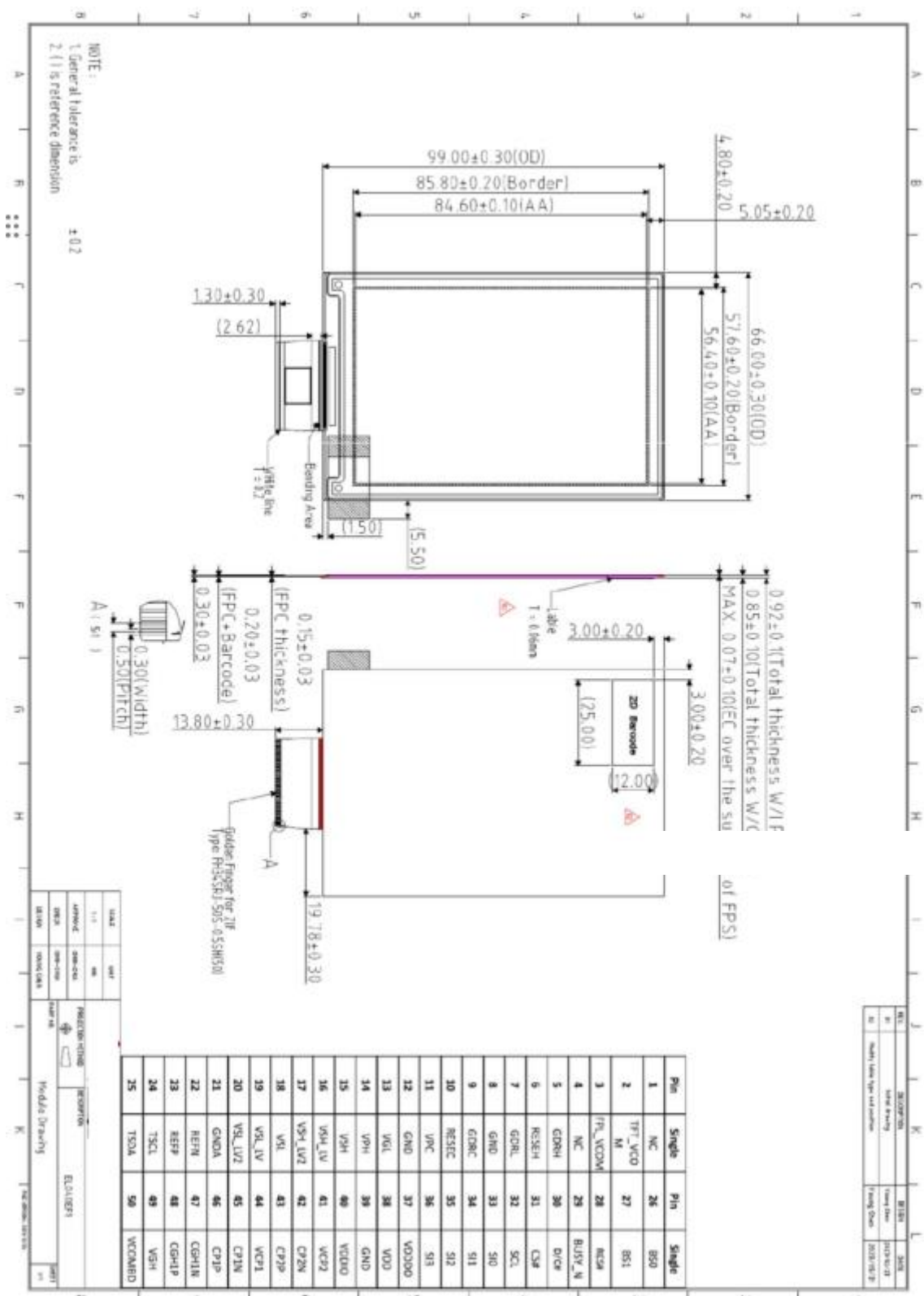
## 2. FEATURES

- ✧ High contrast reflective/electrophoretic technology
- ✧ 400(H) x 600(V) display
- ✧ Full colours
- ✧ Ultra wide viewing angle
- ✧ Ultra low power consumption
- ✧ Pure reflective mode
- ✧ Bi-stable display
- ✧ Commercial temperature range
- ✧ Portrait type
- ✧ Glass substrate
- ✧ All in one IC that integrated source driver, gate driver, TCON, PMIC and OTP memory in the module.

### 3. MECHANICAL SPECIFICATION

| Parameter              | Specification                | Unit  | Remark |
|------------------------|------------------------------|-------|--------|
| Screen Size            | 4.0                          | Inch  |        |
| Display Resolution     | 400(H) x 600(V)              | Pixel |        |
| Active Area            | 56.4(H) x 84.6(V)            | mm    |        |
| Pixel Pitch            | 0.141(H) x 0.141(V)          | mm    | 180PPI |
| Pixel Configuration    | Square                       |       |        |
| Outline Dimension      | 66.0 (H) × 99.0(V) × 0.85(D) | mm    | W/oPF  |
| Module Weight          | 11.92±1.19                   | g     |        |
| Display Operating Mode | Reflective Mode              |       |        |
| Surface Treatment      | AG                           |       |        |

#### 4. MECHANICAL DRAWING OF EPD MODULE



## 5. INPUT/OUTPUT INTERFACE

### 5.1 CONNECTOR TYPE: GOLDEN FINGER FOR ZIF TYPE FH34RJ-50S-0.5SH(50)

#### 5.1.1 PIN ASSIGNMENT

| NO. | Type | Name     | Description                                                                            |
|-----|------|----------|----------------------------------------------------------------------------------------|
| 1   |      | NC       | No connection and do not connect with other NC pins                                    |
| 2   | P    | TFT_VCOM | TFT_VCOM driving voltage                                                               |
| 3   | P    | FPL_VCOM | FPL_VCOM driving voltage                                                               |
| 4   |      | NC       | NC                                                                                     |
| 5   | I/O  | GDRH     | N-channel MOSFET Gate Drive Control                                                    |
| 6   | I/O  | RESEH    | Current Sense Input for the Control Loop                                               |
| 7   |      | GDRL     | Reserved                                                                               |
| 8   | P    | GND      | Ground                                                                                 |
| 9   | I/O  | GDRC     | P-channel MOSFET Gate Drive Control                                                    |
| 10  | I/O  | RESC     | Current Sense Input for the Control Loop                                               |
| 11  | P    | VPC      | VPC driving voltage                                                                    |
| 12  | P    | GND      | Ground                                                                                 |
| 13  | P    | VGL      | Negative Gate driving voltage                                                          |
| 14  | P    | VPH      | VPH driving voltage                                                                    |
| 15  | P    | VSH      | Positive Source driving voltage                                                        |
| 16  | P    | VSH_LV   | Positive Source driving voltage                                                        |
| 17  | P    | VSH_LV2  | Positive Source driving voltage                                                        |
| 18  | P    | VSL      | Negative Source driving voltage                                                        |
| 19  | P    | VSL_LV   | Negative Source driving voltage                                                        |
| 20  | P    | VSL_LV2  | Negative Source driving voltage                                                        |
| 21  | P    | GNDA     | Ground; Connect to GND                                                                 |
| 22  |      | REFN     | Reserved                                                                               |
| 23  |      | REFP     | Reserved                                                                               |
| 24  | O    | TSCL     | I2C Interface to digital temperature sensor Clock pin                                  |
| 25  | I/O  | TSDA     | I2C Interface to digital temperature sensor Data pin                                   |
| 26  | I    | BS0      | Bus selection pin; L: 4-wire IF. H: 3-wire IF. (Default)                               |
| 27  | I    | BS1      | Bus selection pin; L: refer to BS0. (Default) H: Standard 4-wire SPI/dual SPI/quad SPI |
| 28  | I    | RES#     | Reset                                                                                  |
| 29  | O    | BUSY_N   | Busy state output pin                                                                  |
| 30  | I    | D/C#     | Data /Command control pin (D/C)                                                        |
| 31  | I    | CS#      | Chip Select input pin (CSB)                                                            |
| 32  | I    | SCL      | Serial clock pin (SPI)                                                                 |
| 33  | I/O  | SI0      | Serial data pin (SPI)                                                                  |

| NO. | Type | Name   | Description                           |
|-----|------|--------|---------------------------------------|
| 34  | I/O  | SI1    | Serial data pin, reserved             |
| 35  | I/O  | SI2    | Serial data pin, reserved             |
| 36  | I/O  | SI3    | Serial data pin, reserved             |
| 37  | P    | VDDDO  | Core logic power pin, Connect to VDDO |
| 38  | P    | VDD    | Supply voltage                        |
| 39  | P    | GND    | Ground, Connect to GNDA               |
| 40  | P    | VDDIO  | Supply voltage                        |
| 41  | P    | VCP2   | Charge Pump Pin                       |
| 42  | P    | CP2N   | Charge Pump Pin                       |
| 43  | P    | CP2P   | Charge Pump Pin                       |
| 44  | P    | VCP1   | Charge Pump Pin                       |
| 45  | P    | CP1N   | Charge Pump Pin                       |
| 46  | P    | CP1P   | Charge Pump Pin                       |
| 47  |      | CGH1N  | Charge Pump Pin, Reserved             |
| 48  |      | CGH1P  | Charge Pump Pin, Reserved             |
| 49  | P    | VGH    | Positive Gate driving voltage         |
| 50  | P    | VCOMBD | VCOMBD driving voltage                |

**Note 5-1:** This pin (CS#) is the chip select input connecting to the MCU. The chip is enabled for MCU communication only when CS# is pulled LOW.

**Note 5-2:** This pin is (D/C#) Data/Command control pin connecting to the MCU. When the pin is pulled HIGH, the data will be interpreted as data. When the pin is pulled LOW, the data will be interpreted as command.

**Note 5-3:** This pin (RES#) is reset signal input. The Reset is active low.

**Note 5-4:** This pin (Busy\_N) is Busy state output pin. When Busy is Low, the operation of chip should not be interrupted and any command should not be issued to the module. The driver IC would put Busy pin Low when the driver IC is working such as:

- Outputting display waveform; or
- Programming with OTP
- Communicating with digital temperature sensor

**Note 5-5:** This pin (BS0) is for 3-line SPI or 4-line SPI selection. When it is “Low”, 4-line SPI is selected.

When it is “High”, 3-line SPI (9 bits SPI) is selected. Please refer to below Table:

**Table: Bus Interface Selection**

| <b>BS1 State</b> | <b>MCU Interface</b>                                   |
|------------------|--------------------------------------------------------|
| L                | 4-line serial peripheral interface (SPI)               |
| H                | 3- line serial peripheral interface (SPI) - 9 bits SPI |



## 6. ELECTRICAL CHARACTERISTICS

### 6.1 ABSOLUTE MAXIMUM RATING

| Parameter            | Symbol                | Min  | Max  | Unit |
|----------------------|-----------------------|------|------|------|
| Logic supply voltage | VDD                   | +2.4 | +3.6 | V    |
| Tst                  | Storage Temperature   | -25  | 60   | °C   |
| Top                  | Operating Temperature | 0    | 50   | °C   |

**Note 6-1:** Maximum ratings are those values beyond which damages to the device may occur.

**Note 6-2:** Functional operation should be restricted to the limits by Chapter “6. Electrical Characteristics”.

## 6.2 PANEL DC CHARACTERISTICS

The following specifications apply for: VDD = 3.0V, TA = 25°C

| DIGITAL DC CHARACTERISTICS |                                 |                                |             |          |             |      |
|----------------------------|---------------------------------|--------------------------------|-------------|----------|-------------|------|
| Symbol                     | Parameter                       | Conditions                     | Min.        | Typ.     | Max.        | Unit |
| VDD                        | Logic supply voltage            | -                              | 2.4         | 3.0      | 3.6         | V    |
| VGH                        | Positive Gate driving voltage   | -                              | 19.0        | 20.0     | 21.0        | V    |
| VGL                        | Negative Gate driving voltage   |                                | -21.0       | -20.0    | -19.0       | V    |
| VSH                        | Positive source driving voltage | -                              | 14.5        | 15.0     | 15.5        | V    |
| VSL                        | Negative source driving voltage | -                              | 15.5        | -15.0    | -14.5       | V    |
| VCOM_DC                    | VCOM_DC output voltage          | -                              | -4.0        | Adjusted | -0.3        | V    |
| VCOM_AC                    | VCOM_AC output voltage          | -                              | VSL+VCOM_DC | -        | VSH+VCOM_DC | V    |
| VIL                        | Low level input voltage         | Digital Input Pins             | 0           | -        | 0.2 x VDD   | V    |
| VIH                        | High level input voltage        | Digital Input Pins             | 0.8xVDD     | -        | VDD         | V    |
| VOH                        | High level output voltage       | Digital Input Pins<br>IOH=8 mA | 0.8xVDD     | -        | -           | V    |
| VOL                        | Low level output voltage        | Digital Input Pins<br>IOL=8 mA | 0           | -        | 0.2xVDD     | V    |
| IMSTB                      | Module stand-by current         | Stand-by mode                  | -           | 55.6     | -           | uA   |
| IMDS                       | Module deep sleep current       | Deep sleep mode                | -           | 1.1      | -           | uA   |
| Inc                        | Inrush Current                  | High loading pattern           | -           | 61.7     | 65.4        | mA   |
| IMOPR                      | Module Operating Current        | TYP loading pattern            | -           | 15.4     | 22.7        | mA   |

|       |                             |                                             |    |       |       |    |
|-------|-----------------------------|---------------------------------------------|----|-------|-------|----|
|       |                             | High loading pattern                        |    | 32.3  | 48.3  |    |
| P     | Operation Power Dissipation | TYP loading pattern<br>VDD=3.0V with DC-DC  | -- | 46.2  | 68.2  | mw |
|       |                             | High loading pattern<br>VDD=3.0V with DC-DC |    | 96.9  | 144.9 |    |
| PSTBY | Standby Power Dissipation   | VDD=3.0V                                    | -  | 166.8 | -     | uw |

**Note 6-3:** The module operating current data is measured by using oscilloscope, and extract the mean value.

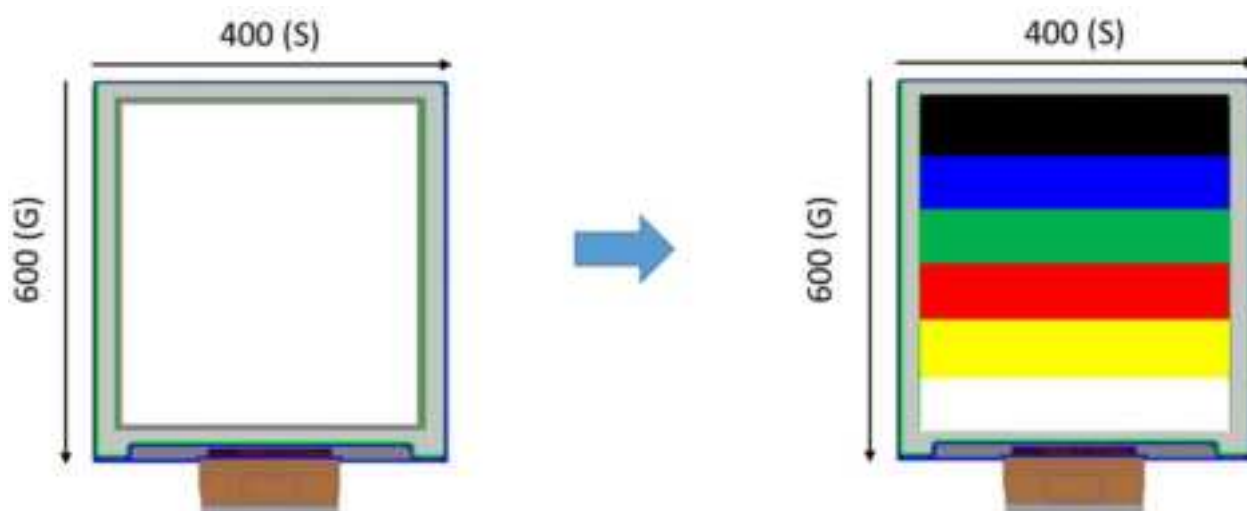
**Note 6-4:** The typical power consumption is measured using associated 25C waveform with following pattern transition: from full white pattern to color stripe pattern. (Note 6-8)

**Note 6-5:** The high loading (Max) power consumption is measured using associated 25C waveform with following pattern transition: from full white pattern to noise pattern (including random scattering of 6 colors). (Note 6-9)

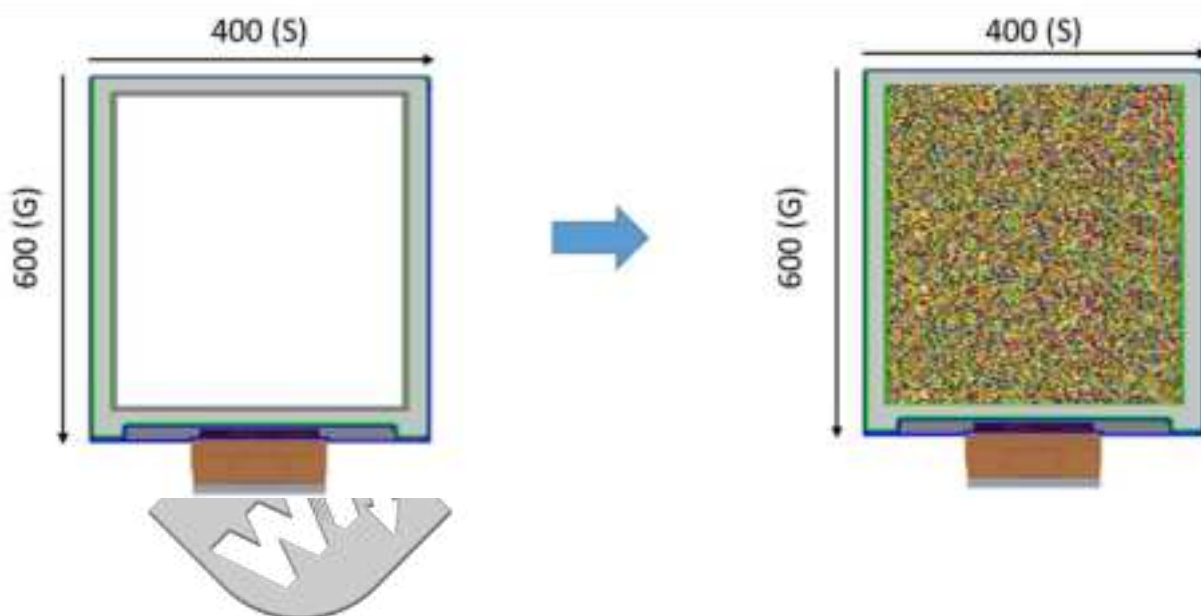
**Note 6-6:** The listed electrical/optical characteristics are only guaranteed under the controller & waveform provided by E Ink.

**Note 6-7:** Vcom value has been set in the IC on the panel.

**Note 6-8:** The typical power consumption



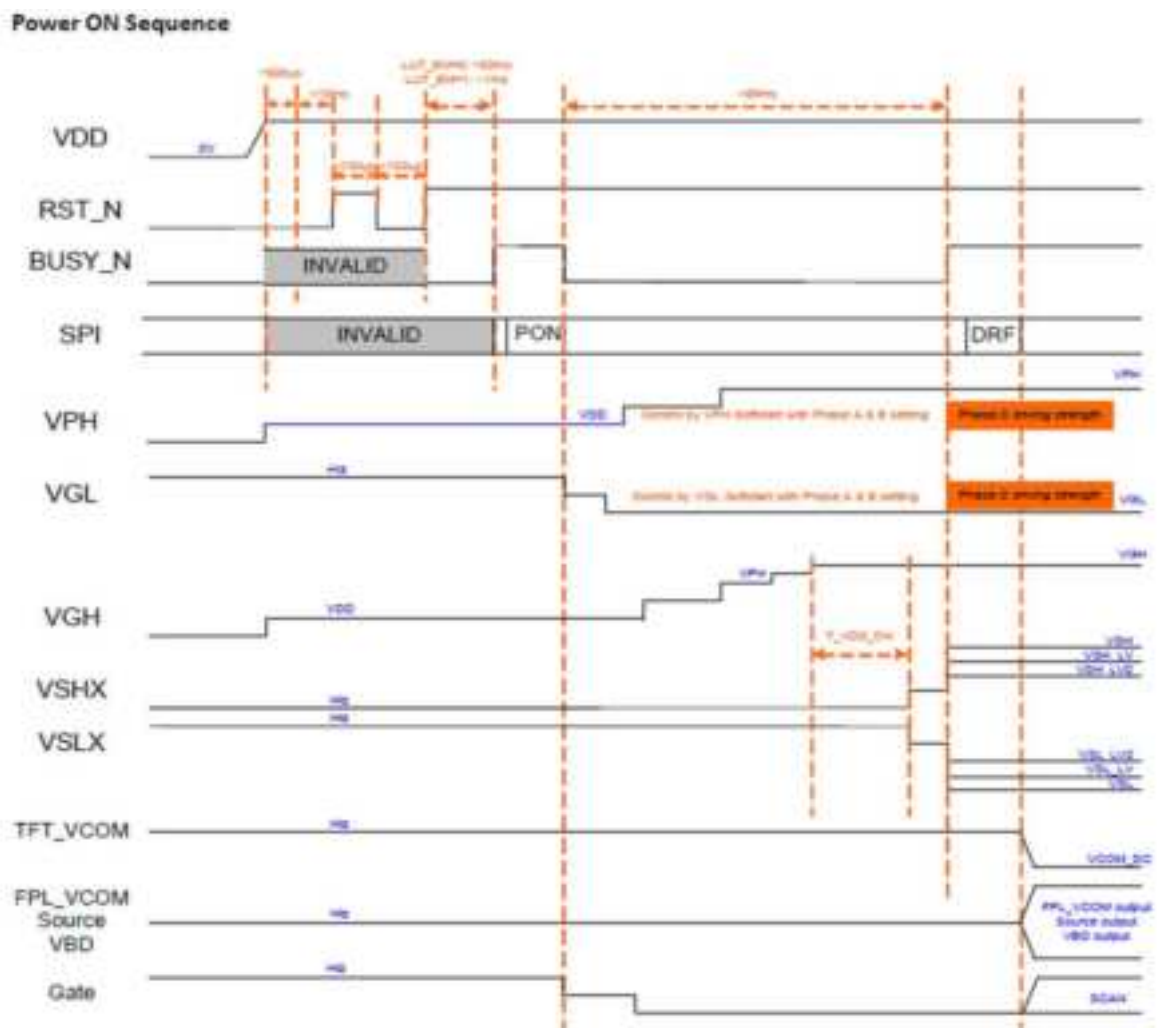
**Note 6-9: The high loading power consumption**



## 7. POWER SEQUENCE

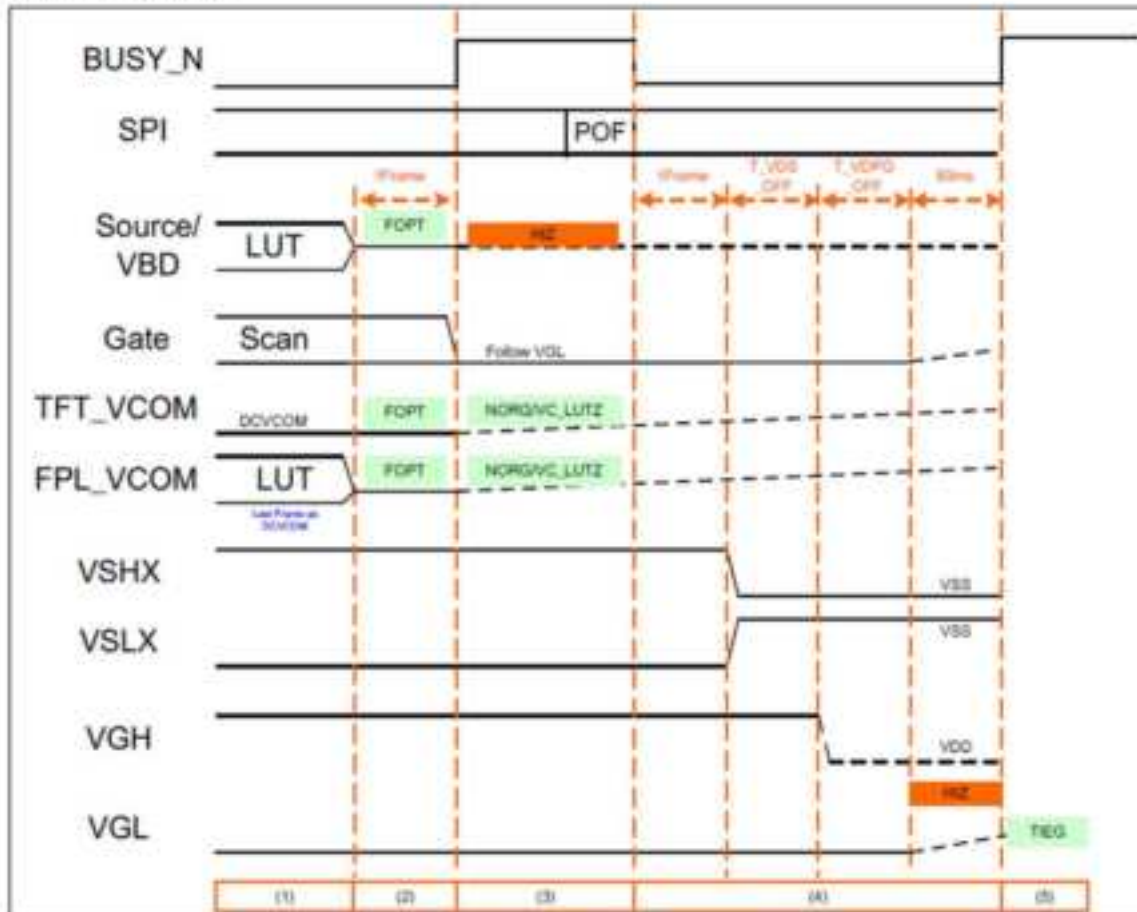
In order to prevent IC fail in power on resetting, the power sequence must be followed as below:

### 7.1 POWER ON SEQUENCE DISPLAY



## 7.2 POWER OFF SEQUENCE DISPLAY

Power OFF Sequence



## 8. OPTICAL CHARACTERISTICS

### 8.1 SPECIFICATION

Measurements are under illumination 45/0, the detector is perpendicular to surface unless otherwise specified.

| Symbol   | Parameter      | Conditions | Temperature | Min | Typ. | Max | Units | Notes |
|----------|----------------|------------|-------------|-----|------|-----|-------|-------|
| R        | Reflectance    | White      | 25°C        | 30  | 34   | -   | %     | 8-1   |
| CR       | Contrast Ratio | -          | 25°C        | 15  | 22   | -   |       | -     |
| T update | update time    | -          | 25°C        | -   | 12   | -   | sec   | -     |

| Symbol | Parameter             | Conditions | Temperature | L*Typ. | a*Typ. | b*Typ. | $\Delta E_{2000}$<br>Max. | Notes |
|--------|-----------------------|------------|-------------|--------|--------|--------|---------------------------|-------|
| WS     | White state L*/a*/b*  | White      | 25°C        | 66.5   | -4     | 0      | 6                         | 8-1   |
| DS     | Dark state L*/a*/b*   | Dark       | 25°C        | 12     | 7      | -11    | 6                         | 8-1   |
| RS     | Red state L*/a*/b*    | Red        | 25°C        | 26.5   | 41     | 30     | 6                         | 8-1   |
| YS     | Yellow state L*/a*/b* | Yellow     | 25°C        | 62     | -11    | 65     | 6                         | 8-1   |
| BS     | Blue state L*/a*/b*   | Blue       | 25°C        | 34     | 3.5    | -37    | 6                         | 8-1   |
| GS     | Green state L*/a*/b*  | Green      | 25°C        | 35     | -22    | 15     | 8                         | 8-1   |

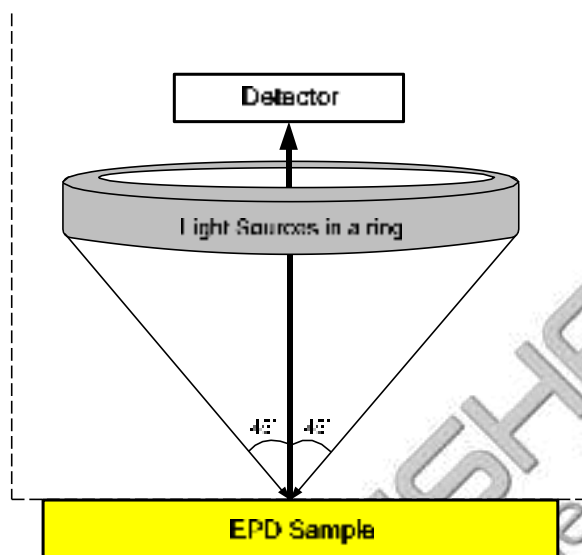
**Note 8- 1: Luminance meter: Eye-One Pro plus Spectrophotometer.**

**WS: White state, DS: Dark state, RS: Red state, YS: Yellow state, BS: Blue state, GS: Green state**

## 8.2 DEFINITION OF CONTRAST RATIO

The contrast ratio (CR) is the ratio between the reflectance in a full white area (RI) and the reflectance in a dark area (Rd):

$$CR = R_I / R_d$$



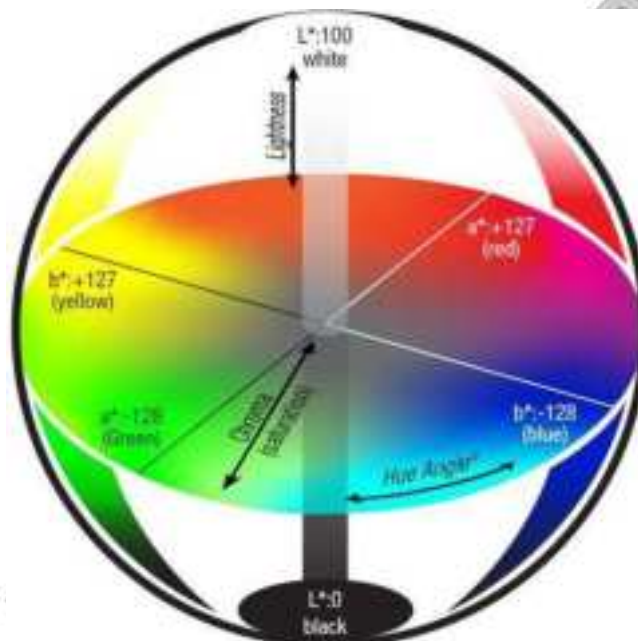
### 8.3 REFLECTION RATIO

The reflection ratio is expressed as:

$$R = \text{Reflectance Factor}_{\text{white board}} \times (L_{\text{center}} / L_{\text{white board}})$$

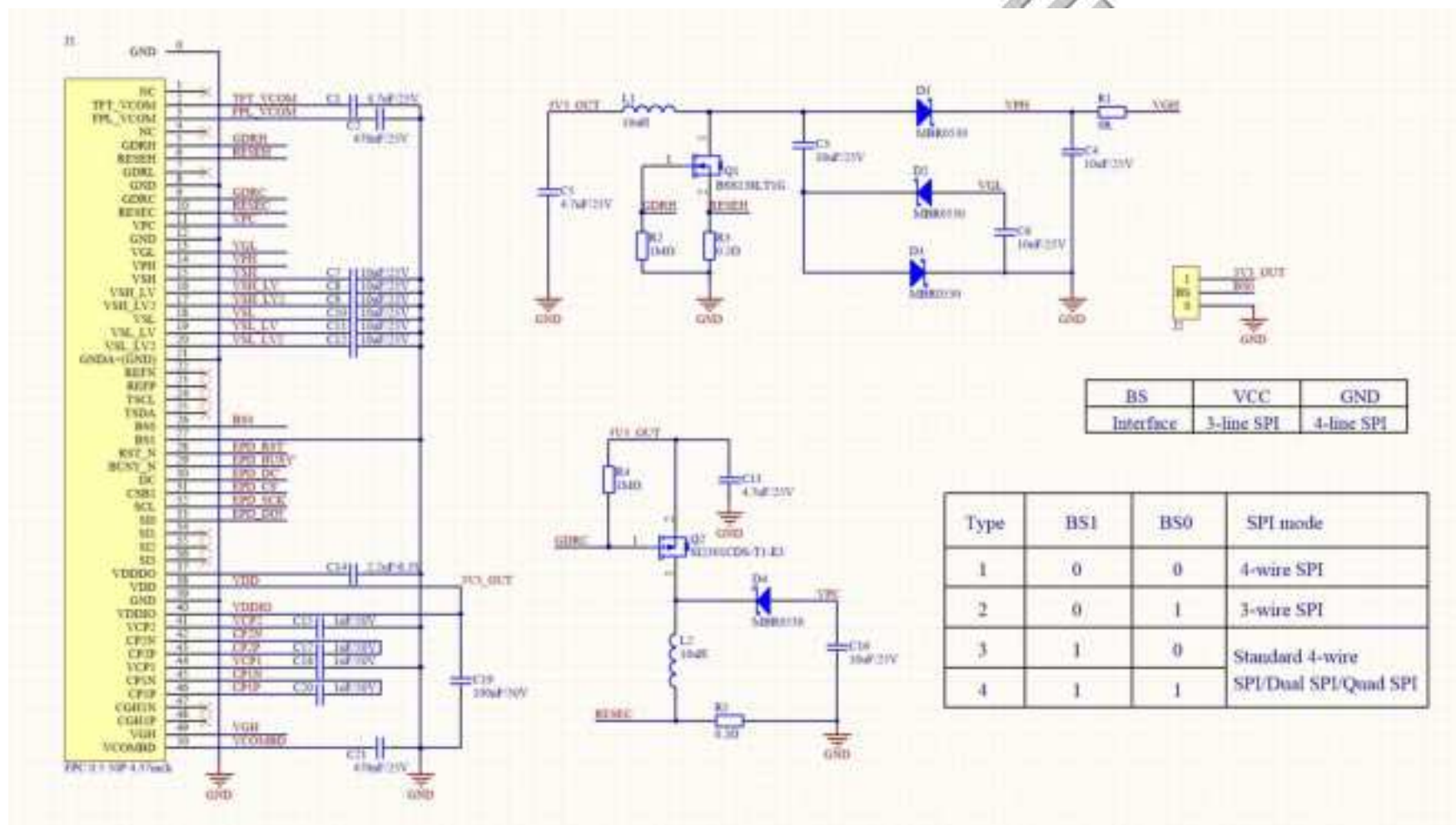
$L_{\text{center}}$  is the luminance measured at center in a white area ( $a^* \sim b^* \sim 0$ ).  $L_{\text{white board}}$  is the luminance of a standard white board. Both are measured with equivalent illumination source. The viewing angle shall be no more than 2 degrees.

### 8.3 DEFINITION OF COLOR PERFORMANCE & SATURATION RATIO



The Spectroradiometer One Pro3 plus was used to measure color image to obtain  $L^*$ ,  $a^*$ ,  $b^*$ . Collect  $L^*$ ,  $a^*$ ,  $b^*$  and then determine the color space.

## 9. REFERENCE CIRCUIT



## 10. HANDLING, SAFETY, AND ENVIRONMENT REQUIREMENTS

### **WARNING**

The display glass may break when it is dropped or bumped on a hard surface. Handle with care. Should the display break, do not touch the electrophoretic material. In case of contact with electrophoretic material, wash with water and soap.

### **CAUTION**

The display module should not be exposed to harmful gases, such as acid and alkali gases, which corrode electronic components. Disassembling the display module.

Disassembling the display module can cause permanent damage and invalidates the warranty agreements.

IPA solvent can only be applied on active area and the back of a glass. For the rest part, it is not allowed.

The module storage environment must under reliability test storage item's criteria.

### **Mounting Precautions**

(1) It's recommended that you consider the mounting structure so that uneven force (ex. Twisted stress) is not applied to the module.

(2) It's recommended that you attach a transparent protective plate to the surface in order to protect the EPD. Transparent protective plate should have sufficient strength in order to resist external force.

(3) You should adopt radiation structure to satisfy the temperature specification.

(4) Acetic acid type and chlorine type materials for the cover case are not desirable because the former generates corrosive gas of attacking the PS at high temperature and the latter causes circuit break by electro-chemical reaction.

(5) Do not touch, push or rub the exposed PS with glass, tweezers or anything harder than HB pencil lead. And please do not rub with dust clothes with chemical treatment. Do not touch the surface of PS for bare hand or greasy cloth. (Some cosmetics deteriorate the PS)

(6) When the surface becomes dusty, please wipe gently with absorbent cotton or other soft materials like chamois soaks with petroleum benzene. Normal-hexane is recommended for cleaning the adhesives used to attach the PS. Do not use acetone, toluene and alcohol because they cause chemical damage to the PS.

(7) Wipe off saliva or water drops as soon as possible. Their long time contact with PS causes deformations and color fading.

| Data sheet status                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                        |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|
| Product specification                                                                                                                                                                                                                                                                                                                                                                                                                                     | This data sheet contains final product specifications. |
| Limiting values                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                        |
| Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability. |                                                        |
| Application information                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                        |
| Where application information is given, it is advisory and does not form part of the specification.                                                                                                                                                                                                                                                                                                                                                       |                                                        |
| REMARK                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                        |
| All The specifications listed in this document are guaranteed for module only. Post-assembled operation or component(s) may impact module performance or cause unexpected effect or damage and therefore listed specifications is not warranted after any Post-assembled operation.                                                                                                                                                                       |                                                        |

## 11. RELIABILITY TEST

| NO | Test items                                | Test condition                                                   | Method                  |
|----|-------------------------------------------|------------------------------------------------------------------|-------------------------|
| 1  | High-Temperature Operation                | T = +50°C, RH = 30% for 240 hrs                                  | IEC 60 068-2-2Be        |
| 2  | Low-Temperature Storage                   | T = 0°C for 240 hrs                                              | IEC 60 068-2-1Ae        |
| 3  | High-Temperature, High-Humidity Operation | T = +40°C, RH = 90% for 240 hrs                                  | IEC 60 068-2-78         |
| 4  | Low-Temperature Storage                   | T = -25°C for 240 hrs<br>(Test in white pattern)                 | IEC 60 068-2-1Ab        |
| 5  | High-Temperature High-Humidity Storage    | T = +60°C, RH = 80% for 240hrs<br>(Test in White Pattern)        | IEC 60 068 2-3CA        |
| 6  | High-Temperature Storage                  | T = +60°C, RH = 35% for 240hrs<br>(Test in White Pattern)        | IEC 60 068-2-2Bb        |
| 7  | Temperature Cycle                         | T = -25°C +60°C, 50 Cycle<br>30min 30min (Test in white pattern) | IEC 068-2-14 Nb         |
| 8  | Electrostatic Effect (non-operating)      | (Machine model) $\pm 250$ V 0 $\Omega$ , 200pF                   | IEC 62179,<br>IEC 62180 |

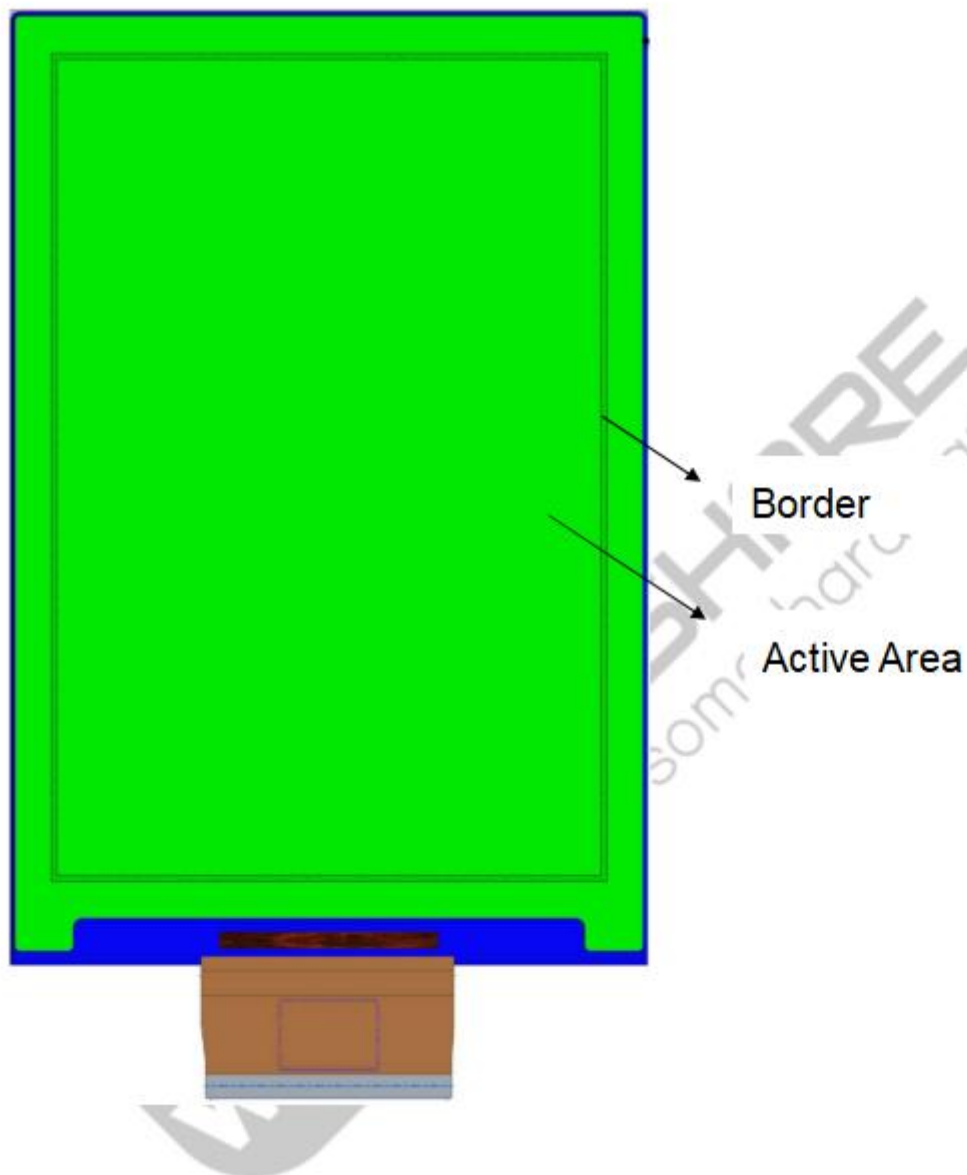
### [Criteria]

In the standard conditions, there is not display function NG issue occurred. (including: line defect ,no image). All the cosmetic specification is judged before the reliability stress.

## 12. BLOCK DIAGRAM

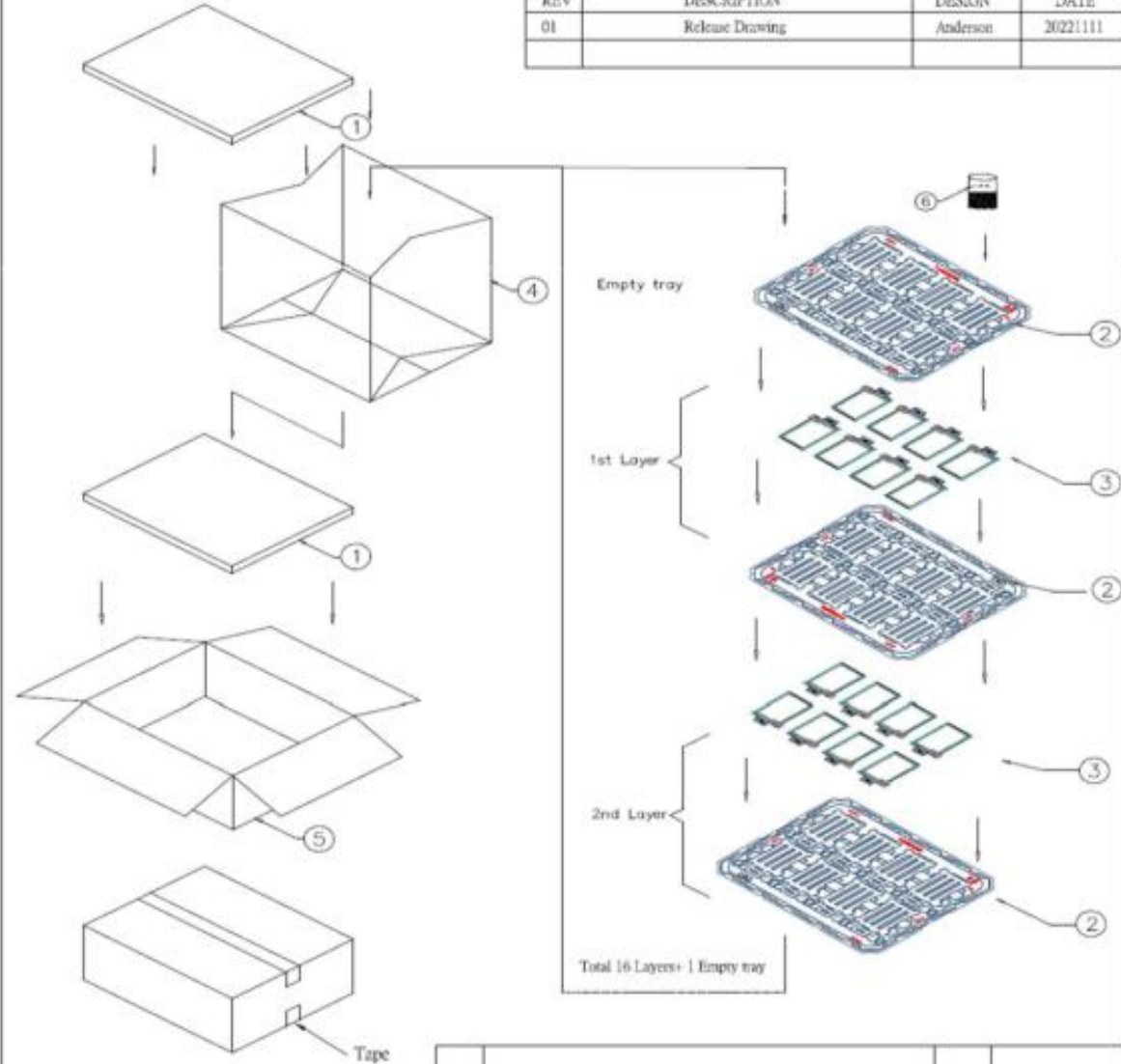


## 13. BORDER DEFINITION



## 14. PACKAGE

| REV | DESCRIPTION     | DESIGN   | DATE     |
|-----|-----------------|----------|----------|
| 01  | Release Drawing | Anderson | 20221111 |



NOTE:

- One layer includes 8pcs panel, 1pcs EPE cushion sheet & 1pcs tray.
- Qty: 128pcs panel/carton.
- Dimension: 455\*375\*190mm
- Make sure tray stacked with 180° rotation. We can check this by tray's half circles from lateral side view.

| ITEM | DESCRIPTION           | Q'TY | REMARK      |
|------|-----------------------|------|-------------|
| 6    | 30g加厚複合紙/古銅乾邊寬73*95mm | 2    |             |
| 5    | CARTON INTERNAL       | 1    |             |
| 4    | 插口紙450*380*580mm      | 1    | ANTI STATIC |
| 3    | EL040EF1              | 128  |             |
| 2    | TRAY                  | 17   | ANTI STATIC |
| 1    | EPE FOAM              | 2    |             |

| APPROVE | CC Chen       | WAVESHARE | DWG. TITLE<br>EL040EF1 Packing Drawing | SHEET<br>1/1 |
|---------|---------------|-----------|----------------------------------------|--------------|
| CHECK   | CC Chen       |           |                                        |              |
| DESIGN  | Anderson Yang |           |                                        |              |