PHOENIX DISPLAY INTERNATIONAL, INC.

# PHOENIX DISPLAY INTERNATIONAL, INC

# SPECIFICATION FOR LCD MODULE

| | |
|---|---|
| **CUSTOMER** | |
| **PART NUMBER** | PDIAT1392AM1B |
| **DESCRIPTION** | 1.4" (400x400) AMOLED |
| **VERSION** | 3.0 |
| **ISSUE DATE** | |

**COMPANY ADDRESS:**
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| Reversion History | | | |
|---|---|---|---|
| Reversion. No | Date | Contents | Remark |
| 01 | 2015-1-13 | First Draft | |
| 02 | 2015-5-15 | Rev. B | |
| 03 | 2015-11-13 | Final Spec | |
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# 1 Scope

This Specification defines AMOLED manufactured by A-TOPS Limited, from here on refer as ARS. In the case of any unspecified item, it may require both A-TOPS and the party designs this module into its product to work out a solution.

# 2 Features

2.1 Product Applications

Smart Watch

2.2 Product Features

1) Display color 16.7M (RGB x 8bits)
2) Display format 1.4"(400RGBx400)
3) Pixel arrangement Real RGB arrangement
4) Interface MIPI 1-lane

# 3 Mechanical Specifications

| Item | Specification | unit |
|---|---|---|
| Dimension outline | 38.6 x 40.5 x 0.67 | mm |
| LTPS Glass outline | 38.6 x 40.5 | mm |
| Encapsulation Glass outline | ϕ38.6 | mm |
| Number of dots | 400(W) x RGB x 400(H) | dots |
| Active area | ϕ35.4 | mm |
| Diagonal size | 1.39 | inch |
| Pixel pitch | 29.5 x 88.5 | μm |
| Glass thickness<br>LTPS/encapsulation glass | 0.2 / 0.2 | mm |
| Weight | 2 | g |

Note: Refer to 9 Outline Dimension Drawing

# 4 Maximum Rating

| Parameter | Symbol | Spec | | | Unit | Note |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Analog/boost power voltage | VCI | -0.3 | - | - | V | - |
| I/O voltage | VDDIO | -0.3 | - | - | V | - |
| Operating temperature | Top | -20 | - | 60 | | - |
| Storage temperature | Tstg | -30 | - | 70 | | - |

# 5 Electrical Specifications

## 5.1 Electrical Characteristics

### 5.1.1 Power Characteristic

| Item | Symbol | Min. | Typ. | Max. | Unit | Remark |
|---|---|---|---|---|---|---|
| AMOLED Power positive | ELVDD | 4.55 | 4.6 | 4.65 | V | - |
| AMOLED power Negative | ELVSS | -2.45 | -2.4 | -2.35 | V | Ref |
| Digital Power supply | VDDIO | 1.65 | 1.8 | 1.95 | V | Ref |
| Analog Power supply | VCI | 2.7 | 2.8 | 2.9 | V | Ref |

**1) Normal Mode**

**Power Supply:** IOVCC=1.8V VCI=2.8V

**Frame Frequency:** $F_{frame}$ =60HZ @ 25degC, Brightness 300 nits, Command Mode,

| Display Condition | Symbol | Min. | Typ. | Max. | Unit | Remark |
|---|---|---|---|---|---|---|
| 100% Pixel On 300nits | IELVDD /ELVSS | - | 21.0 | 25.4 | mA | Ref |
| | IVCI | - | 6.0 | 7.2 | mA | Ref |
| | IVDDIO | - | 6.5 | 7.8 | mA | Ref |
| 50% Pixel On 150nits | IELVDD /ELVSS | - | 5.2 | 6.2 | mA | Ref |
| | IVCI | - | 6.6 | 8.0 | mA | Ref |
| | IVDDIO | - | 6.5 | 7.8 | mA | Ref |
| 10% Pixel On 50nits | IELVDD /ELVSS | - | 0.4 | 0.5 | mA | Ref |
| | IVCI | - | 7.2 | 8.6 | mA | Ref |
| | IVDDIO | - | 6.5 | 7.8 | mA | Ref |

**2) Idle Mode**

**Power Supply:** IOVCC=1.8V VCI=2.8V

**Frame Frequency:** $F_{frame}$ =15HZ @ 25degC, Brightness 30 nits,

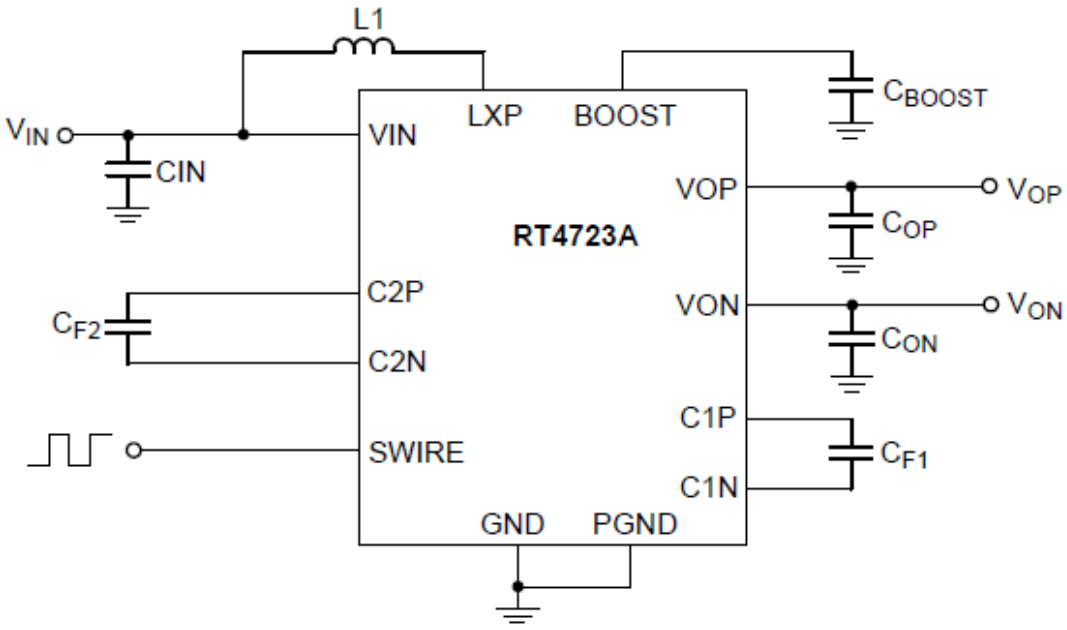
| Display Condition | Symbol | Min. | Typ. | Max. | Unit | Remark |
|---|---|---|---|---|---|---|
| 10% Pixel On 30 nits | IELVDD /ELVSS | - | - | - | mA | Supplied by Driver IC |
| | IVCI | - | 3.0 | 3.6 | mA | Ref |
| | IVDDIO | - | 1.0 | 1.2 | mA | Ref |

**3) DeepStandbyMode**

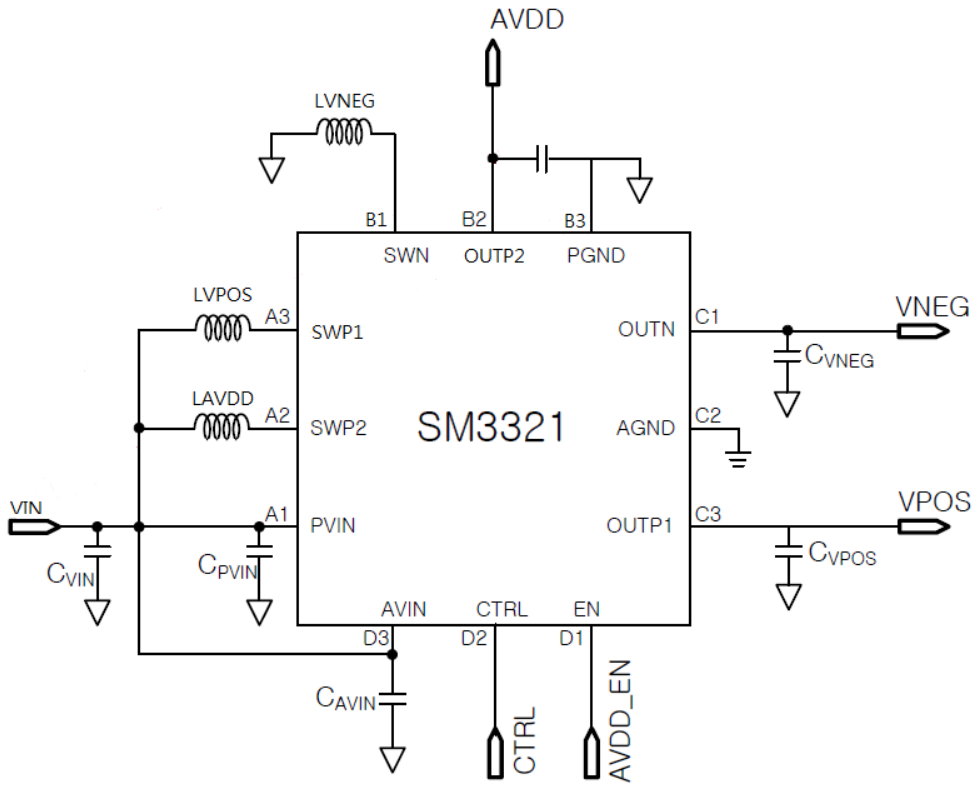
| Display Condition | Symbol | Min. | Typ. | Max. | Unit | Remark |
|---|---|---|---|---|---|---|
| Deep Standby | IVCI | - | - | 1 | uA | - |
| | IVDDIO | - | - | 0 | uA | - |

### 5.1.2 Power supply circuit application (This is for reference only)

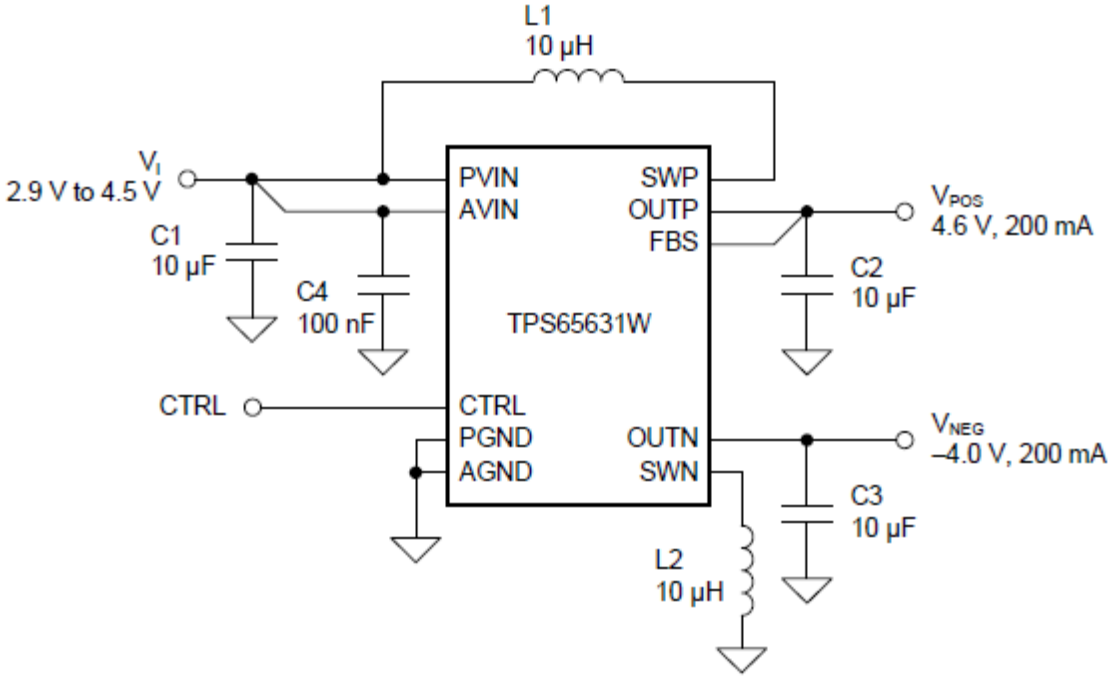
**1) RT4723A**



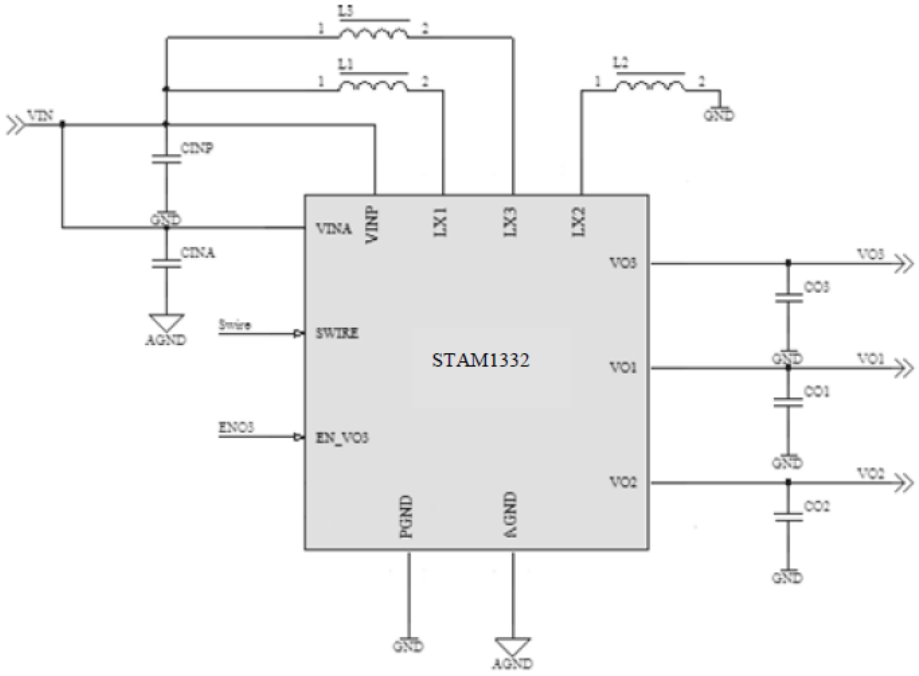

**2) SM3321**




**3) TPS6563W**


L1
10 µH
V_I
2.9 V to 4.5 V
C1
10 µF
C4
100 nF
PVIN
AVIN
SWP
OUTP
FBS
TPS65631W
V_POS
4.6 V, 200 mA
C2
10 µF
CTRL
CTRL
PGND
AGND
OUTN
SWN
V_NEG
–4.0 V, 200 mA
C3
10 µF
L2
10 µH

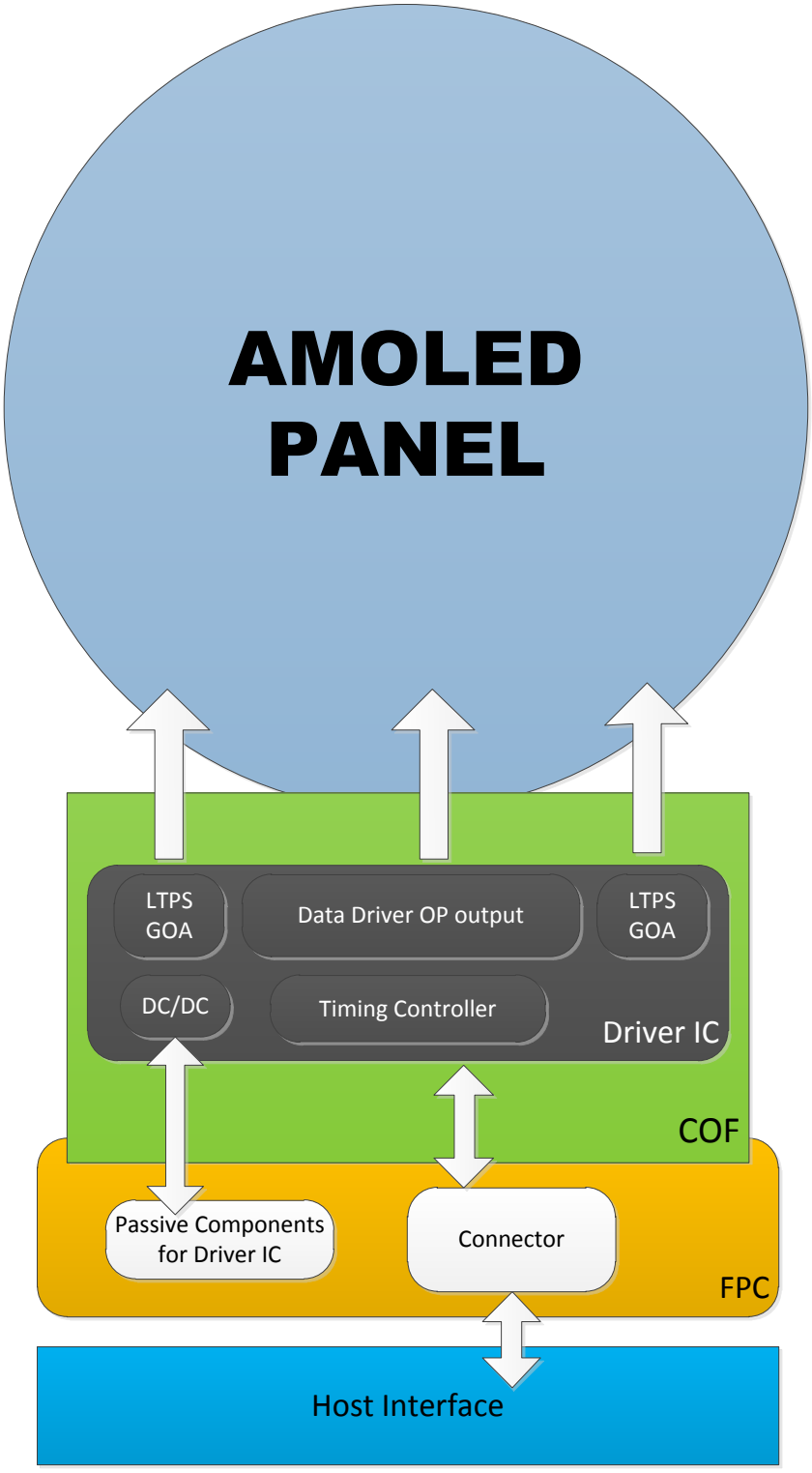
**4) STAM1332**


L3
L1
L2
VIN
CINP
GND
CINA
AGND
Swire
ENO3
VINA
VINP
LX1
LX3
LX2
SWIRE
EN_VO3
PGND
AGND
STAM1332
VO3
VO1
VO2
CO3
CO1
CO2
GND

## 5.2 I/O Connection and Block Diagrams

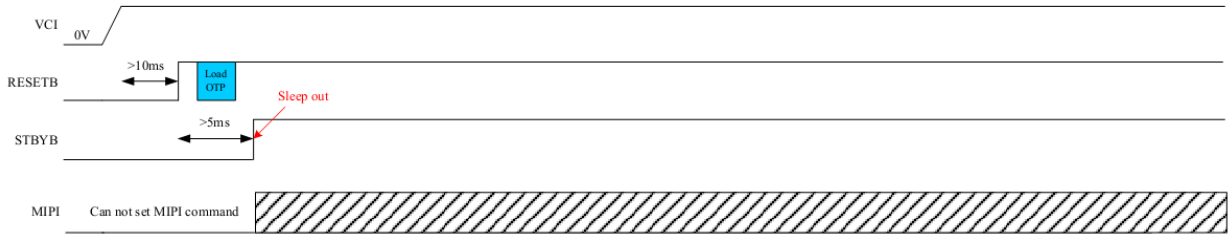
### 5.2.1 I/O Connection

| # | Pin_name | I/O | Description |
|---|---|---|---|
| 1 | ELVSS1 | Power | AMOLED power Negative |
| 2 | ELVDD1 | Power | AMOLED power Positive |
| 3 | ELVSS2 | Power | AMOLED power Negative |
| 4 | ELVDD2 | Power | AMOLED power Positive |
| 5 | ELVSS3 | Power | AMOLED power Negative |
| 6 | ELVDD3 | Power | AMOLED power Positive |
| 7 | VCI | Power | Driver IC analog supply |
| 8 | GND2 | Power | The power ground |
| 9 | VDDIO | Power | Driver IC digital I/O supply |
| 10 | DSI_D0N | I/O | MIPI DSI data0- |
| 11 | GND1 | Power | The power ground |
| 12 | DSI_D0P | I/O | MIPI DSI data0+ |
| 13 | TE | O | Tear effect output |
| 14 | GND3 | Power | The power ground |
| 15 | VPP | Power | Power supply for OTP.<br>Leave the pin to open when not in use. |
| 16 | DSI_CLKN | I/O | MIPI DSI clock- |
| 17 | REST | I | This signal will reset the device and must be applied to properly initialize the chip. Active low. |
| 18 | DSI_CLKP | I/O | MIPI DSI clock+ |
| 19 | SWIRE | O | Swire protocol setting pin of Power IC |
| 20 | GND4 | Power | The power ground |

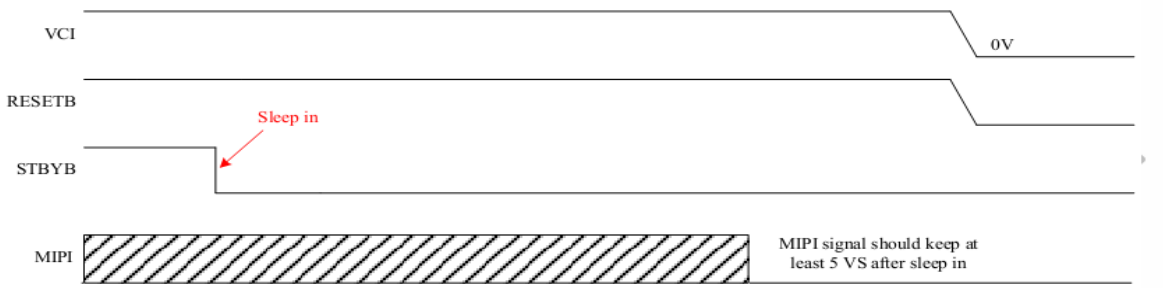

AMOLED
PANEL
LTPS
GOA
Data Driver OP output
LTPS
GOA
DC/DC
Timing Controller
Driver IC
COF
Passive Components
for Driver IC
Connector
FPC
Host Interface

## 5.3 Recommended Operating Sequence

### 5.3.1 Power on sequence

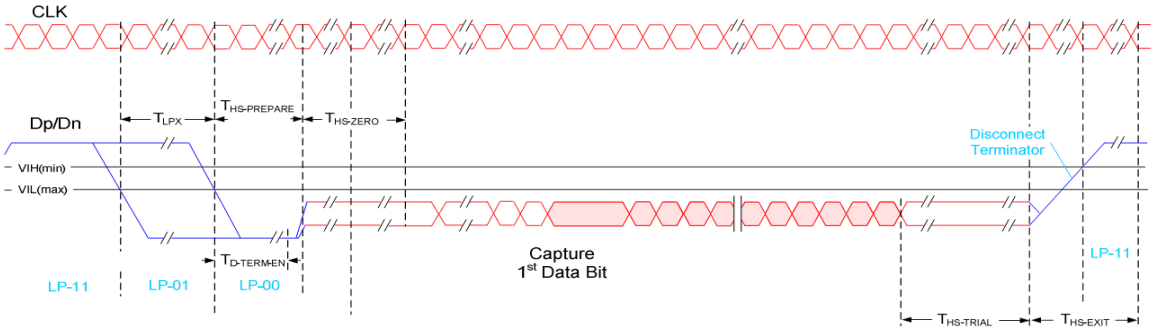



### 5.3.2 Power off sequence

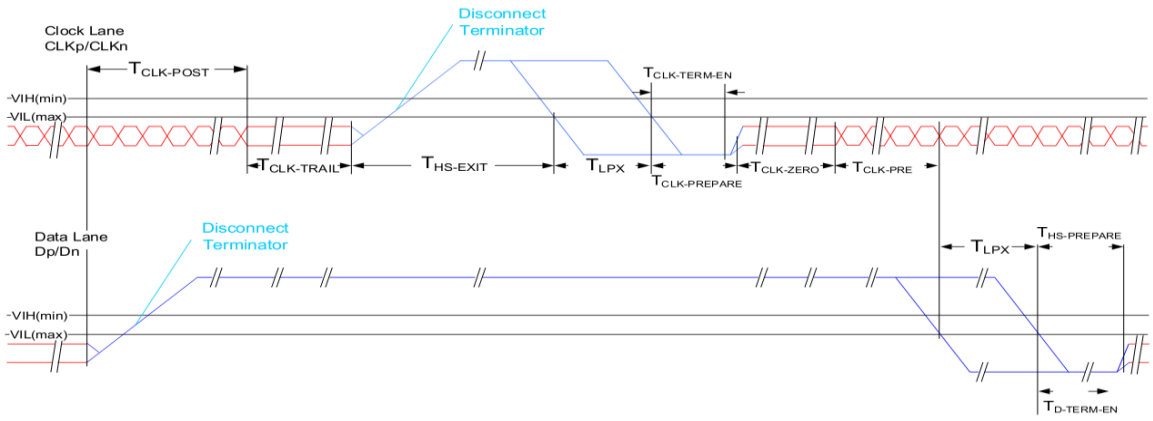



## 5.4 AC Characteristics（MIPI）

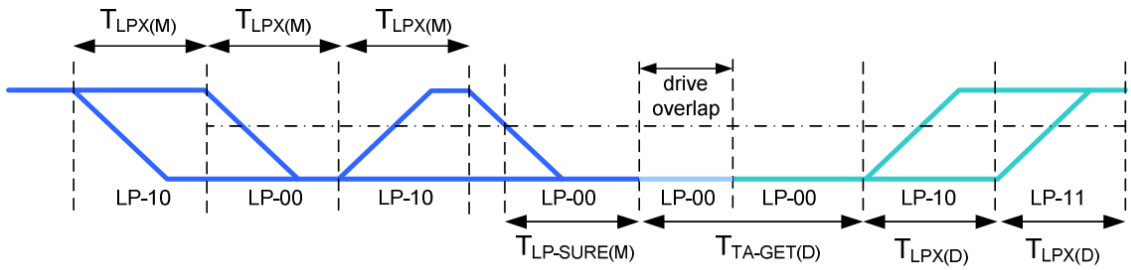
### 5.4.1 HS Data Transmission Burst




### 5.4.2 HS Clock Transmission



### 5.4.3 Turnaround Procedure




### 5.4.4 Timing Parameters

| Symbol | Description | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| TREOT | 30%-85% rise time and fall time | - | - | 35 | ns |
| TCLK-MISS | Timeout for receiver to detect absence of Clock transitions and disable the Clock Lane HS-RX. | - | - | 60 | ns |
| TCLK-POST*1 | Time that the transmitter continues to send HS clock after the last associated Data Lane has transitioned to LP Mode. Interval is defined as the period from the end of THS-TRAIL to the beginning of TCLK-TRAIL. | 60ns + 52*UI (For DCS) | - | - | ns |
| TCLK-PRE | Time that the HS clock shall be driven by the transmitter prior to any associated Data Lane beginning the transition from LP to HS mode. | 8 | - | - | ns |
| TCLK-SETTLE | Time interval during which the HS receiver shall ignore any Clock Lane HS transitions, starting from the beginning of TCLK-PRE. | 95 | - | 300 | ns |
| TCLK-TERM-EN | Time for the Clock Lane receiver to enable the HS line termination,starting from the time point when Dn crosses VIL,MAX. | Time for Dn to reach VTERM-EN | | 38 | ns |
| THS-SETTLE | Time interval during which the HS receiver shall ignore any Data Lane HS transitions, starting from | 85 ns + 6*UI | | 145 ns + 10*UI | ns |

| | | | | | |
|---|---|---|---|---|---|
| | the beginning of THSPREPARE. | | | | |
| TEOT | Time from start of THS-TRAIL or TCLK-TRAIL period to start of LP-11 state | - | - | 105ns+48*UI | ns |
| THS-EXIT(1) | time to drive LP-11 after HS burst | 100 | - | - | ns |
| THS-PREPARE | Time to drive LP-00 to prepare for HS transmission | 40ns + 4*UI | - | 85ns+6*UI | ns |
| THS-PREPARE + THS-ZERO | THS-PREPARE + Time to drive HS-0 before the Sync sequence | 145ns + 10*UI | - | - | ns |
| THS-SKIP | Time-out at RX to ignore transition period of EoT | 40 | - | 55ns+4*UI | ns |
| THS-TRAIL | Time to drive flipped differential state after last payload data bit of a HS transmission burst | 60 + 4*UI | - | - | ns |
| TLPX | Length of any Low-Power state period | 50 | - | - | ns |
| Ratio TLPX | Ratio of TLPX(MASTER)/TLPS(SLAVE) between Master and Slave side | 2/3 | - | 3/2 | ns |
| TTA-GET | Time to drive LP-00 by new TX | 5*TLPX | 5*TLPX | 5*TLPX | ns |
| TTA-GO | Time to drive LP-00 after Turnaround Request | 4*TLPX | 4*TLPX | 4*TLPX | ns |
| TTA-SURE | Time-out before new TX side starts driving | TLPX | - | 2*TLPX | ns |

### 5.4.5 Timing requirements for RESETB

When RESETB of the reset pin equals to Low, it will be in the condition of reset.

When it is in the condition of reset, it will make the device recover the initial set.

However, in order to avoid the reset noise cause reset, there is a mechanism to judge about whether the reset is needed or not.

The closed interval of Low can be shown as the following.

**(Test condition: VDDIO=1.65V~3.6V, VSS=0V, -20 ~+70 )**

| Parameter | Symbol | Conditions | Spec | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| Reset low pulse width | Trst | - | 20 | - | - | μs |

**Table: Reset timing**

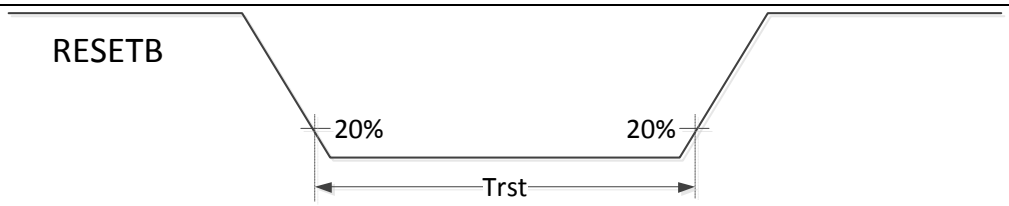



**Figure: Reset timing**

# 6 Electro-Optical Specification

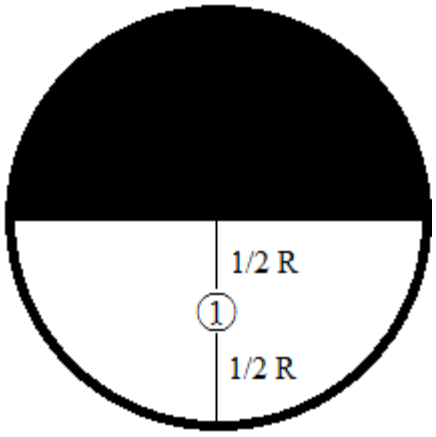
**Test condition** IOVCC=1.8V , VCI=2.8V ,Ta=25

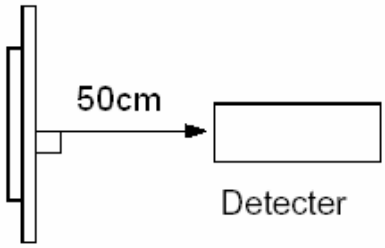
| Item | | Symbol | Condition | Value | | | Unit | Note |
|---|---|---|---|---|---|---|---|---|
| | | | | Min | Typ | Max | | |
| Luminance | | | θ=0° | 250 | 300 | - | cd/m2 | Note 1 |
| Uniformity | | | Φ=0° | 80 | | - | % | Note 2 |
| Viewing Angle | Left | $\theta_L$ | Cr≥200 | 80 | 85 | - | Deg. | Note 3 |
| | Right | $\theta_R$ | | 80 | 85 | - | | |
| | Top | $\psi_T$ | | 80 | 85 | - | | |
| | Bottom | $\psi_B$ | | 80 | 85 | - | | |
| Contrast Ratio | | CR | θ=0° | 5000 | 10000 | - | - | Note 4 |
| Response Time | | Tr+Tf | Φ=0° | - | 2 | 4 | ms | Note 5 |
| Color Coordinate of CIE1931 | Red | X | θ=0° Φ=0° | - | 0.66 | - | - | - |
| | | Y | | - | 0.34 | - | | |
| | Green | X | | - | 0.21 | - | | |
| | | Y | | - | 0.74 | - | | |
| | Blue | X | | - | 0.13 | - | | |
| | | Y | | - | 0.06 | - | | |
| | White | X | | 0.27 | 0.30 | 0.33 | | |
| | | Y | | 0.28 | 0.31 | 0.34 | | |
| NTSC Ratio | | NTSC | CIE1931 | 85 | 100 | - | % | - |
| Flicker | | - | - | - | -30 | - | dB | - |
| Gamma | | - | - | 1.9 | 2.2 | 2.5 | | Note 6 |
| Crosstalk | | Δ CT | - | - | - | 1.1 | | Note 7 |

**Note 1: Luminance measurement**

The test condition is measured on the surface of AMOLED module at 25 .

- Measurement equipment CS2000 or similar equipment (Field of view:1deg,Distance:50cm)
- Measuring surroundings: Dark room.
- Measuring temperature: Ta=25 .
- Adjust operating voltage to get optimum contrast at the center of the display.
- Measuring Pattern:



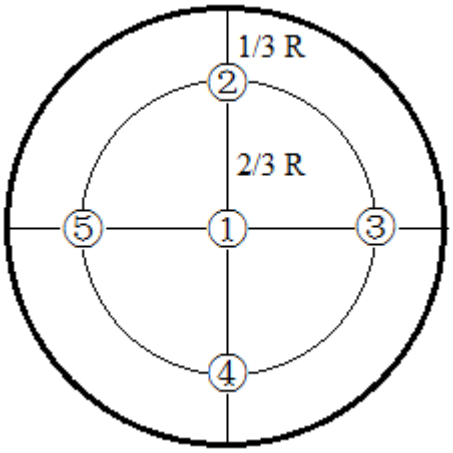

**Note 2: Uniformity**

The luminance uniformity is calculated by using following formula:

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

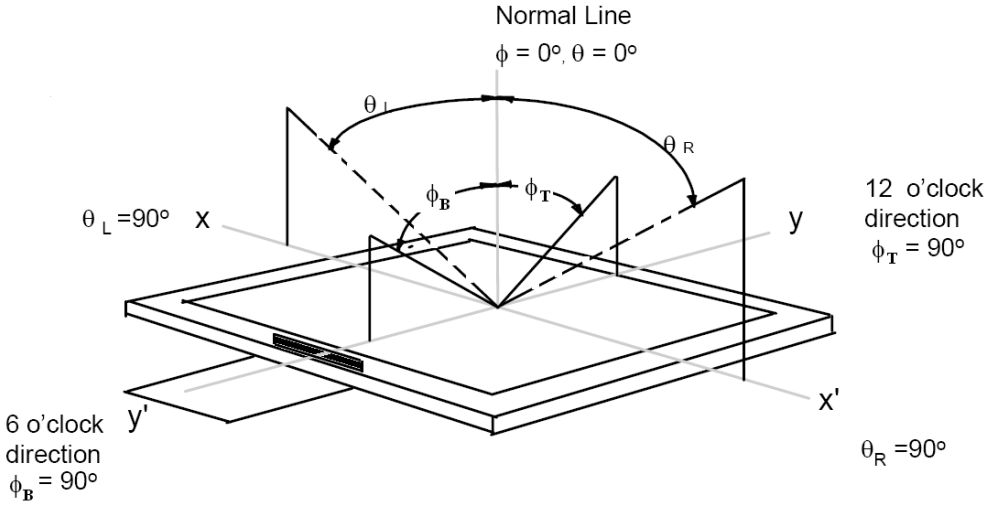
Bp (Max.) = Maximum brightness in 5 measured spots

Bp (Min.) = Minimum brightness in 5 measured spots.




**Note 3**: **The definition ofViewing Angle**

Refer to the graph below marked by $\vartheta$ and $\Phi$

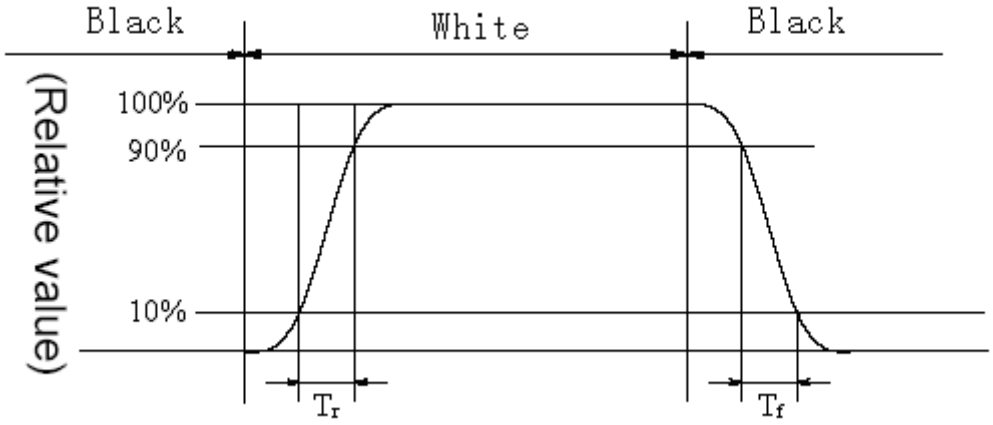


**Note 4**: **The definition of Contrast Ratio**:

$$\text{Contrast Ratio (CR)} = \frac{\text{Luminance When AMOLED is at “White” state}}{\text{Luminance When AMOLED is at “Black” state}}$$

**Note 5**: **Definition of Response time.**

The output signals of photo detector are measured when the input signals are changed from “black” to “white” (Voltage falling time) and from “white” to “black” (Voltage rising time), respectively. The response time is defined as the time interval between the 10% and 90% of amplitudes. Refer to figure as below.



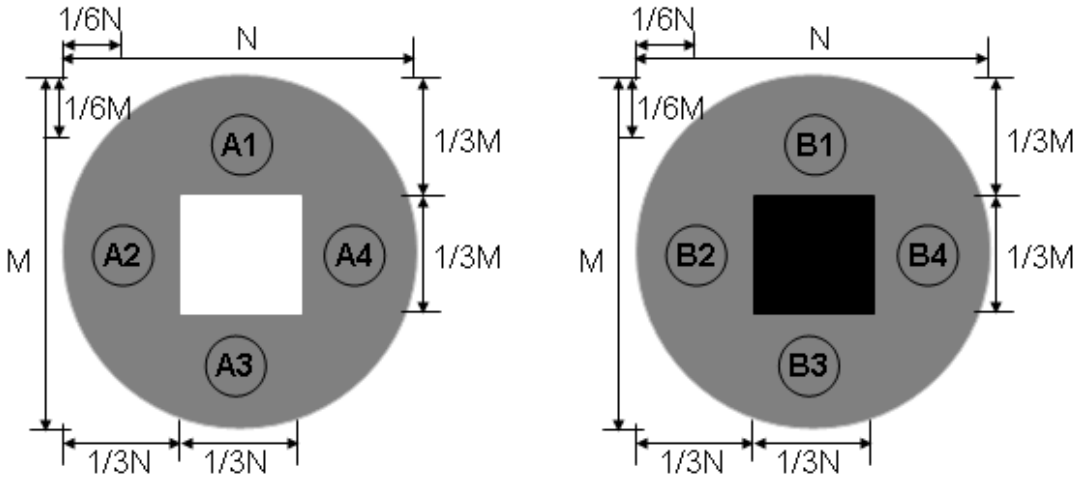

**Note 6: Gamma curve**

The whole curve’s tolerance must control within +/-0.3, test the gray scale below:
8, 16, 25, 33, 41, 49, 58, 66, 74, 82, 90, 99, 107, 115, 123, 132, 140, 148, 156, 165, 173, 181, 189, 197,206, 214, 222, 230, 239, 247

**Note 7**: **Crosstalk**

There should be no visible cross-talk in normal direction of the display when the two “Cross-talk Test Patterns” below are loaded.

△Bp (Max.) = Maximum value in △Bp1~△Bp4.
△Bp (Min.) = Minimum value in △Bp1~△Bp4.
△CT=△Bp (Max.)/ △Bp(Min.).
△CT must be less than 1.10




**Crosstalk Test Pattern**

# 7 Reliability

## 7.1 Environmental Test

| Item | Main spec | No. of failures / No. of examinations | Note |
|---|---|---|---|
| High Temperature Operation | 70 / 128hours | 0/5 | |
| Low Temperature Operation | -20 / 128hours | 0/5 | |
| High Temperature Storage | 80 / 128hours | 0/5 | |
| Low Temperature Storage | -30 / 128hours | 0/5 | |
| High Temperature Humidity Operation | 60 /90%RH 128hours | 0/5 | |
| Thermal Shock | -40 ~80 0.5hr, 30 cycles | 0/5 | |

## 7.2 Electrical Test

| Item | Main spec | Note |
|---|---|---|
| Air Discharge | ±4kV , 150pF/330Ω (Module level) | 5Points, Each 2times. No degradation of OLED performance after this test. |
| Contact Discharge | ±4kV, 150pF/330Ω (Module level) | |

7.3 Mechanical Test

| Item | Main spec | Note |
|---|---|---|
| Drop Test | Drop the packing from 75cm height, 3 times for 6-faces, 3-edges and 1-corner | Package |
| Vibration-proof test | 2g, f=10->55->10Hz apply in each of X, Y, and Z direction for 30 min | Package |

# 8 Handling Precautions

8.1 When cleaning ITO pad, avoid using hard and abrasive material or corrosive solution

8.2 Keep module away from direct sunlight or fluorescent light, and keep it at room temperature and humidity

8.3 Strong impact & pressure on module and packing is prohibited

8.4 Following normal power on/off sequence is necessary for preventing abnormal display or permanent damage to display

8.5 Optimal contrast ratio under ideal voltage is AMOLED module's characteristic, hence it is recommended a voltage control function available

8.6 Image sticking may occur if an image displays for an extended period of time

8.7 When interfered by system's overall mechanical design, an abnormal display may occur

8.8 After considering emitting energy, you should plan your design to satisfy EMI standards.

8.9 Host side should place a surge-prevent circuit at power trace (ie: VCI, Vddi) to protect AMOLED module.

# 9 Outline Dimension Drawing

