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## Product Specifications

<b>Customer</b>	<b>Standard</b>
<b>Description</b>	<b>1.44" TFT EPD Panel</b>
<b>Model Name</b>	<b>E2144CS021</b>
<b>Date</b>	<b>2016/12/21</b>
<b>Doc. No.</b>	<b>1P134-00</b>
<b>Revision</b>	<b>01</b>

<b>Customer Approval</b>	
<b>Date</b>	
<p>The above signature represents that the product specifications, testing regulation, and warranty in the specifications are accepted</p>	

	<b>Design Engineering</b>		
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**Revision History**

Version	Date	Page (New)	Section	Description
Ver.01	2016/12/21	All	All	Product specification first issued.

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## Glossary of Acronyms

EPD	Electrophoretic Display (e-Paper Display)
EPD Panel	EPD
EPD Module	EPD with TCon board
TCon	Timing Controller
TFT	Thin Film Transistor
MCU	Microcontroller Unit
FPC	Flexible Printed Circuit
FPL	Front Plane Laminate
SPI	Serial Peripheral Interface
COG	Chip on Glass
IIS	Incoming Inspection Standard
ISTA	International Safe Transit Association
PDI	Pervasive Displays Incorporated



## 1 General Description

### 1.1 Overview

This is a 1.44" a-Si, active matrix TFT, Electronic Paper Display (EPD) panel. The panel has such high resolution (111dpi) that it is able to easily display fine patterns. Due to its bi-stable nature, the EPD panel requires very little power to update and needs no power to maintain an image.

### 1.2 Features

- a-Si TFT active matrix Electronic Paper Display(EPD)
- Resolution: 128 x 96
- Ultra low power consumption
- Super Wide Viewing Angle - near 180°
- Extra thin & light
- SPI interface
- RoHS compliant

### 1.3 Applications

- Electronic shelf label (ESL)
- Reusable container
- Badge

## 1.4 General Specifications

**Table 1-1 General Specification**

Item	Specification	Unit	Note
Outline Dimension	40.5(H) x 28.8(V) x 1.0(T)	mm	(1)
Active Area	58.0(H) x 32.0(V)	mm	
Driver Element	a-Si TFT active matrix	-	
FPL	Aurora Mb	-	
Pixel Number	128 x 96	pixel	
Pixel Pitch	0.229 x 0.229 (111 dpi)	mm	
Pixel Arrangement	Vertical stripe	-	
Display Colors	Black/White	-	
Surface Treatment	Anti-Glare	-	

Note (1): Not including FPC and Masking Film

## 1.5 Mechanical Specifications

**Table 1-2 Mechanical Specification**

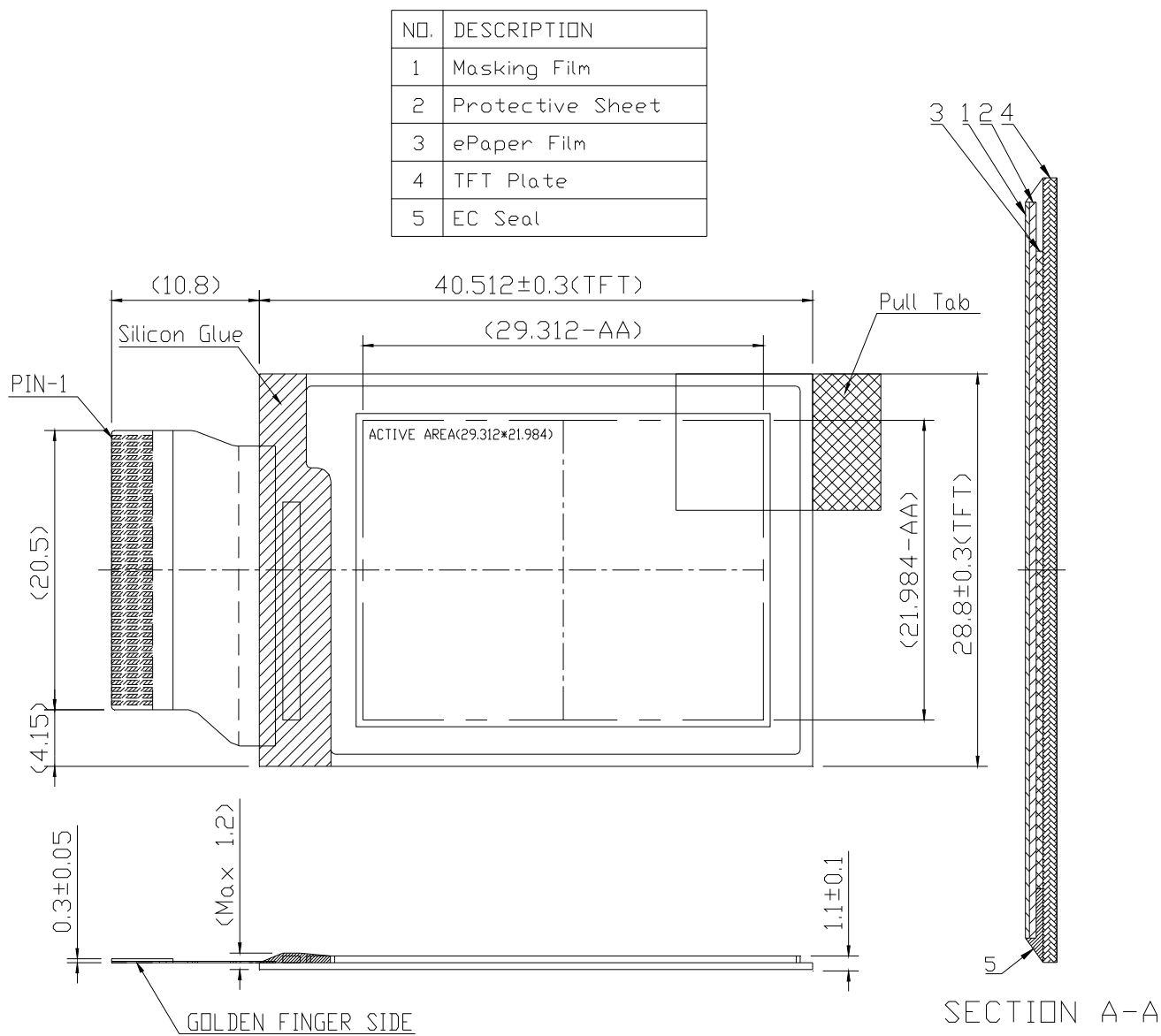
Item		Min.	Typ.	Max.	Unit	Note
Glass Size	Horizontal(H)	40.2	40.5	40.8	mm	
	Vertical(V)	28.5	28.8	29.1	mm	
	Thickness(T)	0.9	1.0	1.1	mm	(1)
Weight		-	2.86	3.44	g	

Note (1): Not including the Masking Film.

**Table 1-3 FPC Specification**

Item	Pin numbers	Pitch (mm)	Connector	Note
Golden Finger	40	0.5	STARCONN 089H40 or HRS TF31-40S or Compatible	

**Figure 1-1 EPD Drawing**



**General tolerance: ±0.3mm**

## 2 Absolute Maximum Ratings

### 2.1 Ratings of Environment

**Table 2-1 Absolute Ratings of Environment**

Item	Symbol	Value		Unit	Note
		Min.	Max.		
Storage Temperature	T <sub>ST</sub>	-20	+60	°C	(1),(3)
Absolute Storage Humidity	H <sub>ST</sub>	30	90	%RH	(1),(3)
Operating Ambient Temperature	T <sub>OP</sub>	0	+50	°C	(1),(2),(4)
Operating Ambient Humidity	H <sub>OP</sub>	30	90	%RH	(1),(2),(4)
Optimal Storage Temperature	T <sub>STo</sub>	-10	35	°C	(1),(3)
Optimal Storage Humidity	H <sub>STo</sub>	40	60	%RH	(1),(3)

Note (1):

- (a) 90 %RH Max. ( $T_a \leq 40$  °C), where  $T_a$  is ambient temperature.
- (b) Wet-bulb temperature should be 39 °C Max. ( $T_a > 40$  °C).
- (c) No condensation and no frost in absolute ratings of Environment.

Note (2): The temperature of panel display surface area should be 0 °C Min. and 50 °C Max. Refresh time depends on operation temperature.

Note (3): E Ink Material is Moisture and UV sensitive. The absolute rating operating environments describes the boundary conditions for updating the display while the absolute rating storage environment describe the boundary conditions for a display not updating. While displays are rated to perform according to specification for the warranty period at the absolute specified operating environment, the better the storage condition, the better the E Ink displays will perform. Similar to other moisture and UV sensitive components, we recommend that our displays be stored in temperature and humidity control environments, and whenever possible, under above defined Optimal Storage Condition, away from sunlight, to optimize their performance.

Note (4): The performance of EPD may be degraded under sunlight. Please customer consults PDI if customer wants to use EPD under sunlight.

## 2.2 Reliability Test Item

**Table 2-2 Reliability Test Items**

Item	Test Condition	Remark
High Temperature Operation	50 °C/30%RH for 240h	(1) (2)
Low Temperature Operation	0 °C for 240h	(1) (2)
High Temperature/Humidity Operation	40 °C / 90 %RH for 240h	(1) (2)
High Temperature Storage	60 °C / 30%RH for 240h	(1) (2)(3)
Low Temperature Storage	-20 °C for 240h	(1) (2) (3)
High Temperature/Humidity Storage	60 °C / 80 %RH for 240h	(1) (2) (3)
Thermal Cycles ( Non-operation )	1 Cycle:-20°C/30min → 60°C/30min, for 100 Cycles	(1) (2) (3)
Package Drop Test	Drop from 97cm. ( ISTA ) 1 corner, 3 edges, 6 sides. One drop for each.	(1) (2) (3)
Package Random Vibration Test	1.15Grms, 1Hz ~ 200Hz. ( ISTA )	(1) (2) (3)

Note (1): No condensation and no frost during test. End of test, function, mechanical, and optical shall be satisfied with product specification and IIS.

Note (2): The test result and judgment are based on PDI's 1bit driving waveform, driving fixture and driving system.

Note (3): Stay white pattern for storage and non-operation test.

## 2.3 Product Lifetime

The EPD Module is designed for a 5-year life-time with 25 °C/50%RH operation assumption. Reliability estimation testing with accelerated life-time theory would be demonstrated to provide confidence of EPD lifetime.

## 2.4 Product Warranty

Warranty conditions have to be negotiated between PDI and individual customers. PDI provides 13months warranty for all products which are purchased from PDI.

### 3 Electrical Characteristics

#### 3.1 Absolute Maximum Ratings of Panel

**Table 3-1 Absolute Maximum Ratings of Panel**

Parameter	Symbol	Value		Unit	Note
		Min	Max		
Digital Power	V <sub>DD</sub>	-0.3	6.0	V	
Analog Power	V <sub>CC</sub>	-0.3	6.0	V	
Ground	V <sub>SS</sub>	-		-	Connect V <sub>SS</sub> to Ground

T<sub>a</sub> = 25 ± 2 °C

#### 3.2 Recommended Operation Conditions of Panel

**Table 3-2 Recommended Operation Conditions of Panel**

Parameter	Symbol	Value			Unit	Note
		Min	Typ	Max		
Digital Power	V <sub>DD</sub>	2.3	3.0	3.6	V	
Analog Power	V <sub>CC</sub>	2.3	3.0	3.6	V	
Input Voltage	High	V <sub>IH</sub>	0.8V <sub>DD</sub>	-	V <sub>DD</sub>	/CS, ID, SCLK, SI, /RESET
	Low	V <sub>IL</sub>	V <sub>SS</sub>	-	0.2V <sub>DD</sub>	
Output Voltage	High	V <sub>OH</sub>	0.8V <sub>DD</sub>	-	V <sub>DD</sub>	I <sub>OH</sub> =0.5mA, SO, BUSY
	Low	V <sub>OL</sub>	V <sub>SS</sub>	-	0.2V <sub>DD</sub>	I <sub>OL</sub> =-0.5mA, SO, BUSY
Input Leakage Current	High	I <sub>IH</sub>	-	-	2.0	uA
	Low	I <sub>IL</sub>	-	-	-2.0	uA
Input Current	I <sub>DD</sub> + I <sub>CC</sub>	-	4	8	mA	(1),(2),(3)
DC/DC Inrush Current	I <sub>PEAK</sub>	-	30	90	mA	(1),(2),(3)

T<sub>a</sub> = 25 ± 2 °C

Note (1):

**Figure 3-1 Test Pattern of Panel**

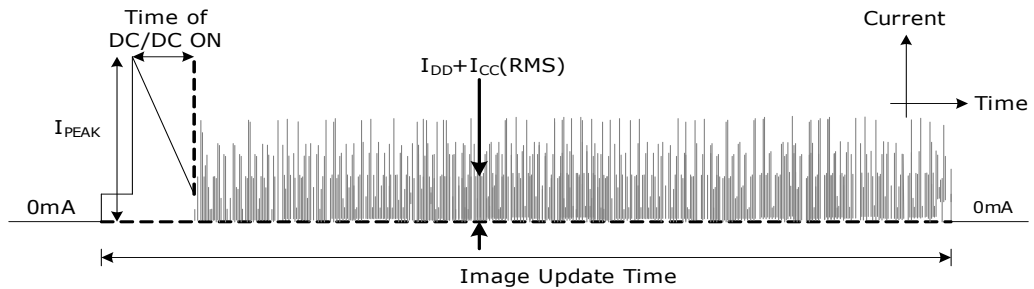


These currents are tested with PDI test jig.

Note (2):

$$V_{DD}=V_{CC}=3.0V$$

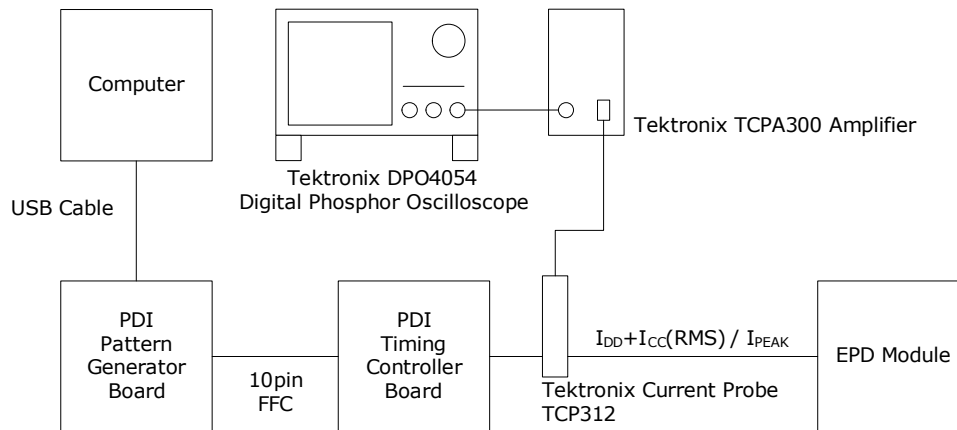
**Figure 3-2 Image Update Current Profile**



The "Time of DC/DC ON" which contains the some current peak of  $V_{GH}/V_{DH}/V_{GL}/V_{DL}/V_{COM}$ .

Note (3):

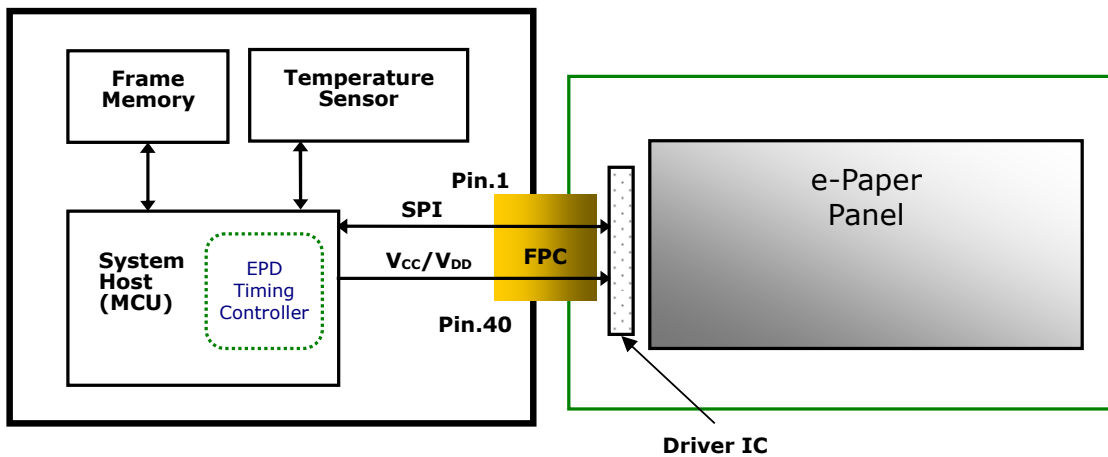
**Figure 3-3 Current Measurement**





## 4 Application Circuit Block Diagram

Figure 4-1 Application Circuit Block Diagram



## 5 Terminal Pin Assignment & Reference Circuit

### 5.1 Terminal Pin Assignment

**Table 5-1 Terminal Pin Assignment**

No.	Signal	Type	Connected to	Function
1	/CS	I	Tcon	Chip Select. Low enable
2	BUSY	O	Tcon	When BUSY = HIGH, EPD stays in busy state that EPD ignores any input data from SPI
3	ID	I	Ground	Connect ID to ground
4	SCLK	I	Tcon	Clock for SPI
5	SI	I	Tcon	Serial input from Timing Controller to EPD
6	SO	O	Tcon	Serial output from EPD to Timing Controller
7	/RESET	I	Tcon	Reset signal. Low enable
8	PWRON	-	NC	Keep open
9	V <sub>CL</sub>	C	Capacitor	-
10	C42P	-	NC	Not Connected
11	C42M	-		
12	C41P	C	Charge-Pump Capacitor	-
13	C41M	C		-
14	C31M	C	Charge-Pump Capacitor	-
15	C31P	C		-
16	C21M	C	Charge-Pump Capacitor	-
17	C21P	C		-
18	C16M	C	Charge-Pump Capacitor	-
19	C16P	C		-
20	C15M	C	Charge-Pump Capacitor	-
21	C15P	C		-

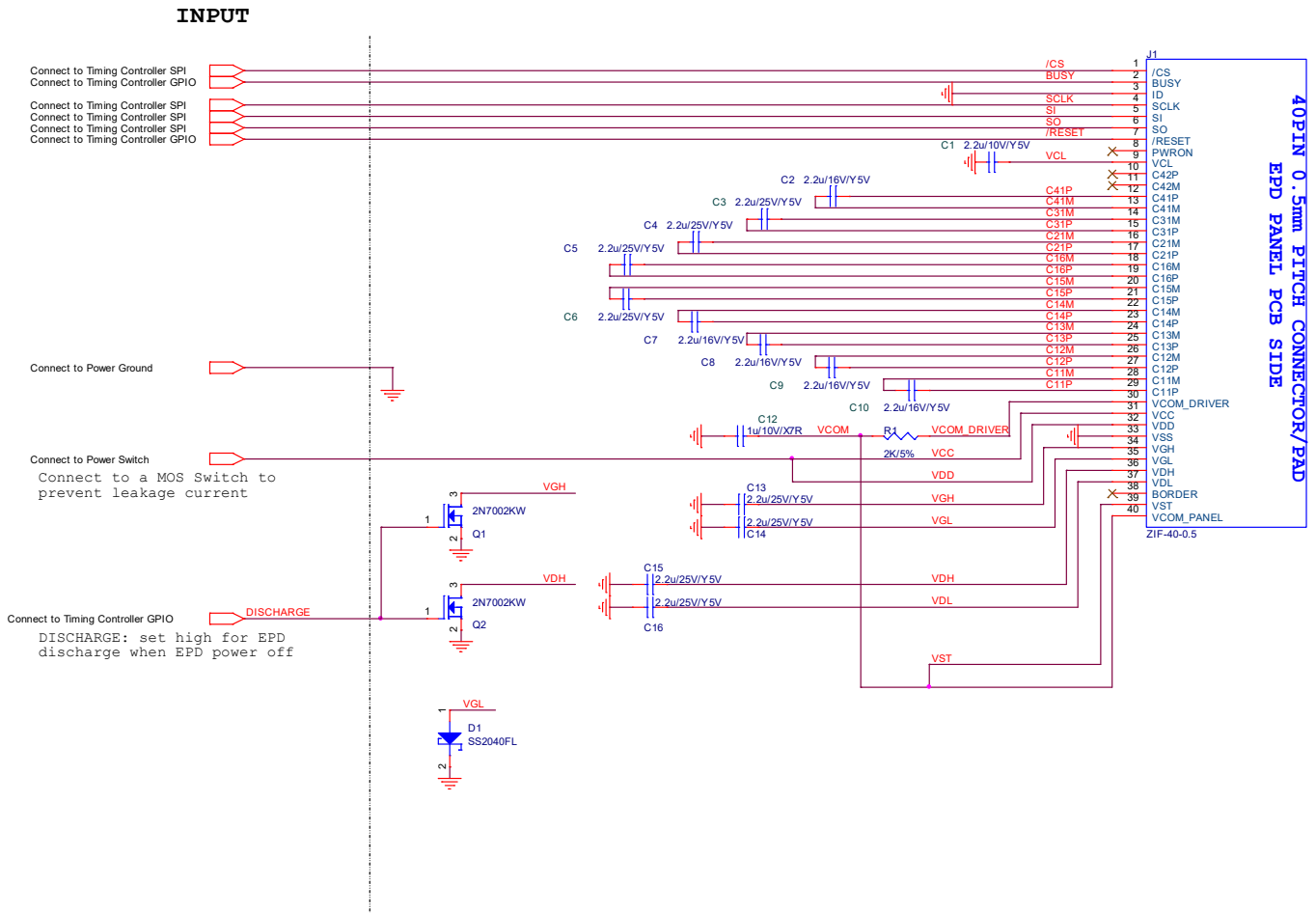
No.	Signal	Type	Connected to	Function
22	C14M	C	Charge-Pump Capacitor	-
23	C14P	C		-
24	C13M	C	Charge-Pump Capacitor	-
25	C13P	C		-
26	C12M	C	Charge-Pump Capacitor	-
27	C12P	C		-
28	C11M	C	Charge-Pump Capacitor	-
29	C11P	C		-
30	V <sub>COM_DRIVER</sub>	RC	Resistor & Capacitor	The signal duty cycle can drive V <sub>COM</sub> voltage from source driver IC
31	V <sub>CC</sub>	P	V <sub>CC</sub>	Power supply for analog part of source driver
32	V <sub>DD</sub>	P	V <sub>DD</sub>	Power supply for digital part of source driver
33	V <sub>SS</sub>	P	Ground	
34	V <sub>GH</sub>	C	Capacitor	
35	V <sub>GL</sub>	C	Capacitor	
36	V <sub>DH</sub>	C	Capacitor	
37	V <sub>DL</sub>	C	Capacitor	
38	BORDER	I	-	Not connected
39	V <sub>ST</sub>	P	V <sub>COM_PANEL</sub>	
40	V <sub>COM_PANEL</sub>	C	Capacitor	V <sub>COM</sub> to panel

Note:

Type: I: Input  
 O: Output  
 C: Capacitor  
 RC: Resistor and Capacitor  
 P: Power

## 5.2 Reference Circuit

Figure 5-1 EPD Reference Circuit



Note: (1)  $V_{DD}$  and  $V_{CC}$  must be discharged promptly after power off.

## 6 Optical Characteristics

### 6.1 Measurement Conditions

**Table 6-1 Optical Measurement Conditions**

Item	Symbol	Value	Unit
Ambient Temperature	Ta	25±2	°C
Ambient Humidity	Ha	50±10	%RH
Supply Voltage	V <sub>CC</sub> & V <sub>DD</sub>	3.0	V

Note: Image is updated with above condition.

### 6.2 Optical Specifications

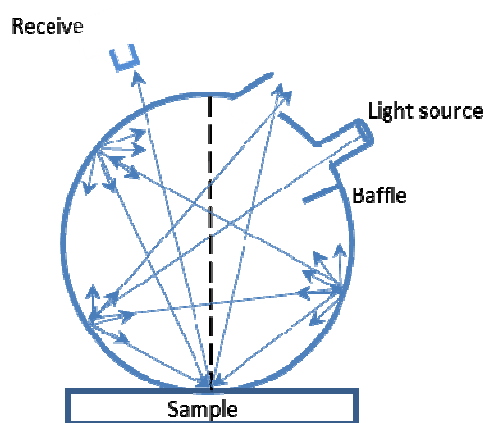
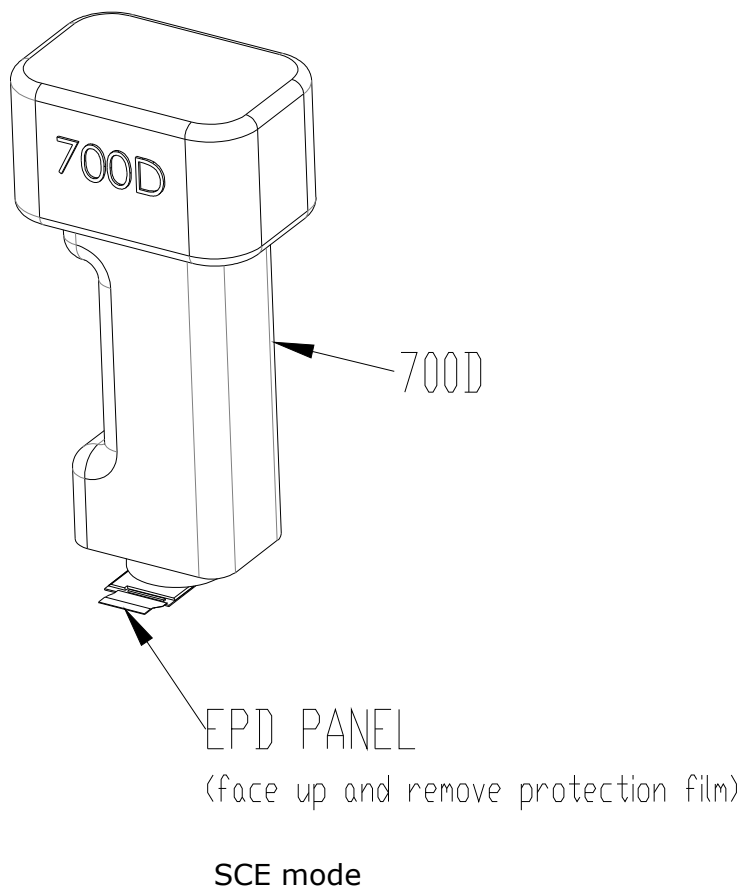
#### 6.2.1 Optical

**Table 6-2 Optical Measurement with D65 light source**

Item	Symbol	Rating			Unit	Note
		Min.	Typ.	Max.		
Contrast ratio	CR	-	13:1	-	-	$\theta_x=\theta_y=0$ (1),(2),(4),(5)
Refresh time	Tr	-	3	-	sec	(1),(3),(5)
White state	L*	-	70	-	-	$\theta_x=\theta_y=0$ (1),(2),(5)
	a*		-2.8			
	b*	-	-0.5	-		
Reflectance	R%	-	42	-	%	(1),(2),(5)

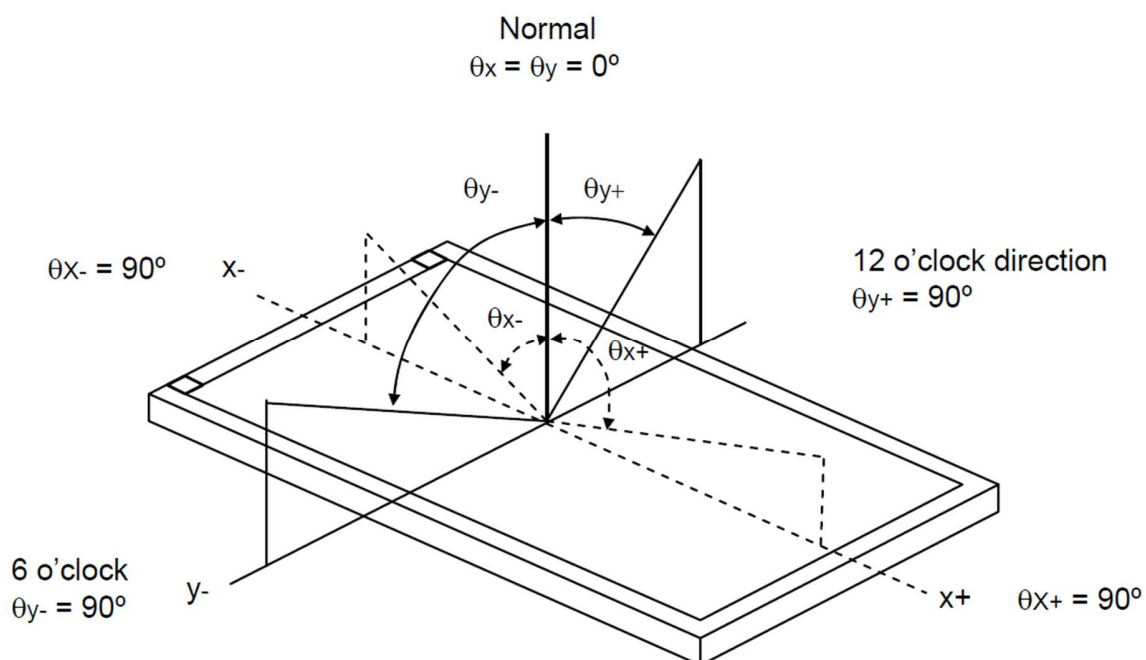
Note (1): Panel is driven by PDI waveform without masking film and optical measurement by CM-700D with D65 light source and SCE mode.

**Figure 6-1 Optical measurement**



Note (2): Definition of Viewing Angle ( $\theta_x$ ,  $\theta_y$ ):

**Figure 6-2 Definition of Viewing Angle to Measure Contrast Ratio**



Note (3): Refresh time is the time that e-paper particles move not including the power on and off time. The refresh time is measured at 25°C. The refresh time and contrast ratio varies due to different films, display performance requirements, and ambient temperatures.

Note (4): Contrast ratio (C.R.): The Contrast ratio is calculated by the following expression.  $C.R. = (R\% \text{ White}) / (R\% \text{ Black})$ .

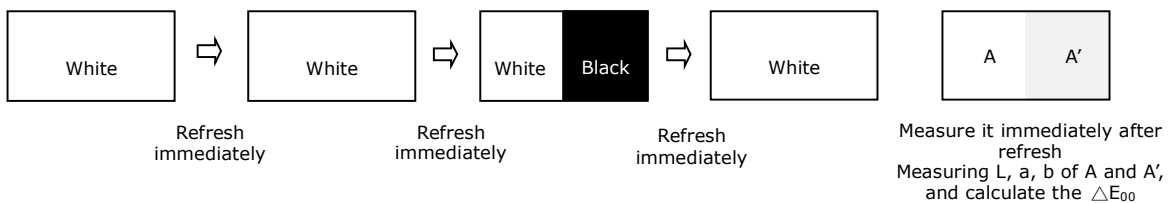
Note (5): Optical data is measured at 60 seconds after refresh with PDI's global update procedure.

### 6.2.2 Ghosting

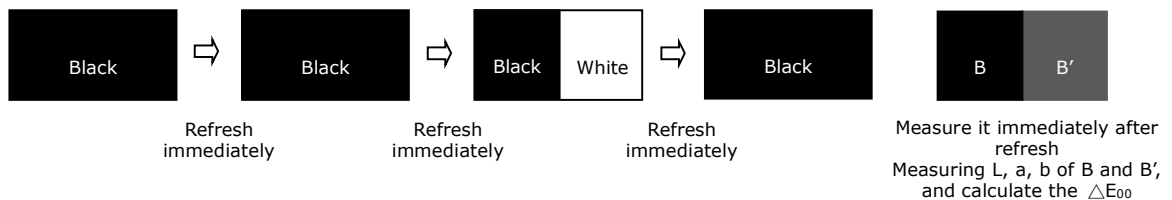
Below are two test methods to verify if ghosting is within an acceptable range. Test 1 and Test 2 use measured data to calculate color different,  $\Delta E_{00}$  (CIEDE 2000).

The condition of measurement is to follow " Table 6-1 Optical Measurement Conditions".

- Test 1: White to Black Ghosting



- Test 2: Black to White Ghosting



**Table 6-3 Measurement of Ghosting**

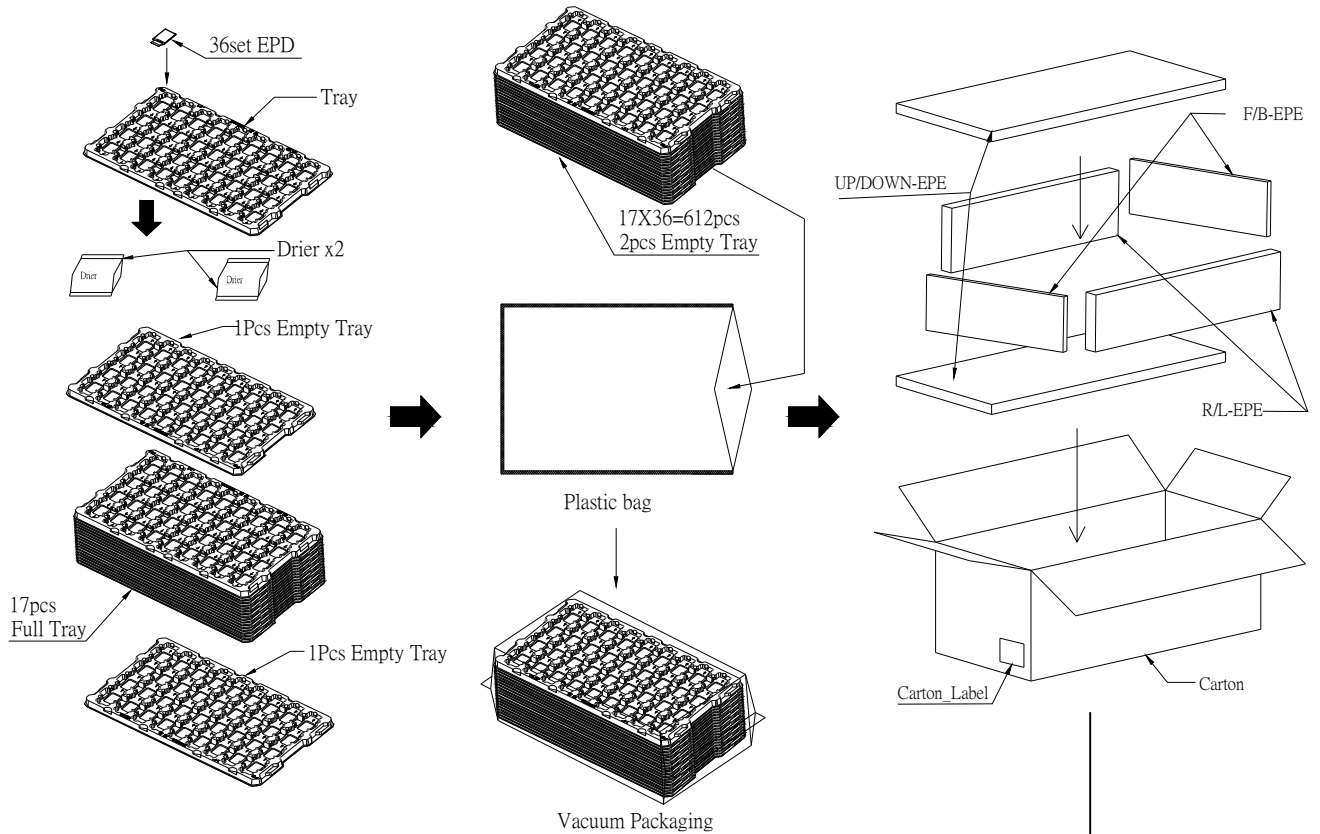
Item	Rating		
	Min.	Typ.	Max.
Test 1 $\Delta E^*_{ab}$	-	-	2
Test 2 $\Delta E^*_{ab}$	-	-	2

Note: Panel is driven by PDI waveform without masking film and optical measurement by CM-700D with D65 light source and SCE mode.

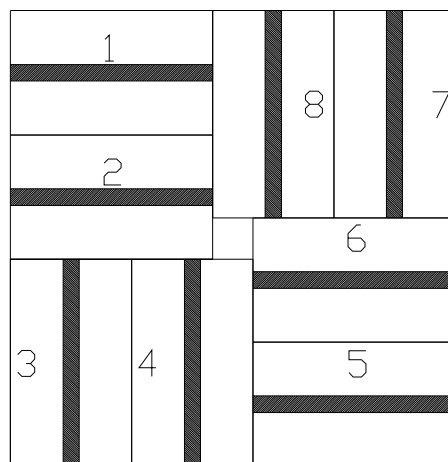


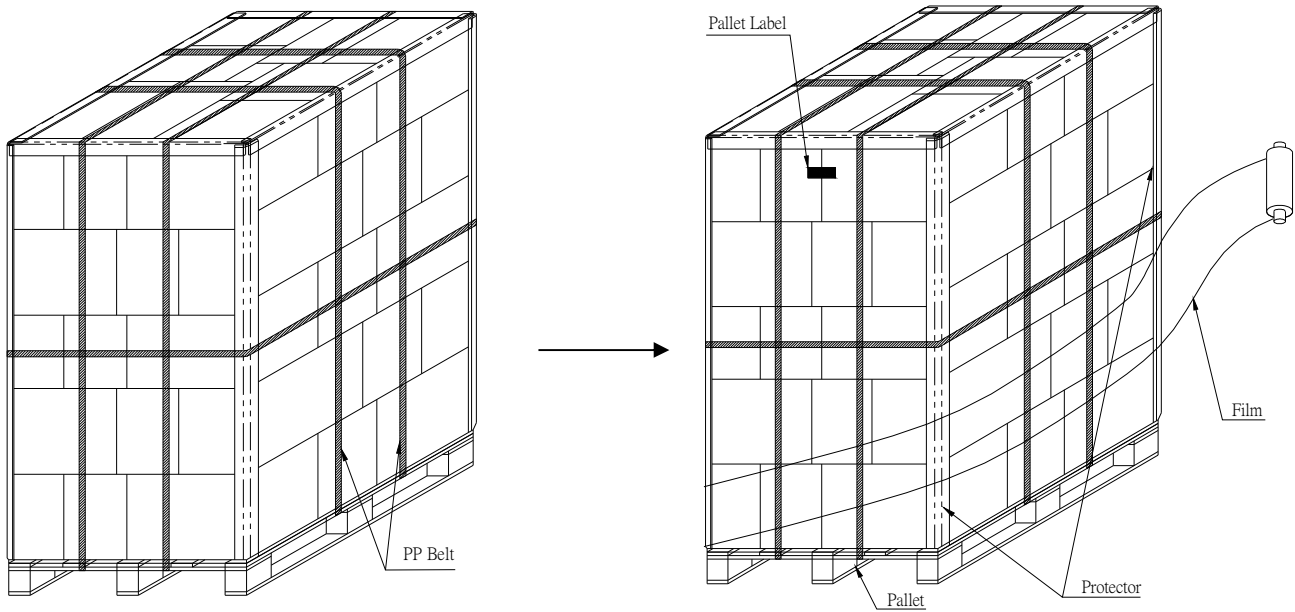
## 7 Packing

Figure 7-1 Packing Diagram



Note: 1. Carton outline size: 500L X 300W X 200H mm  
 2. Material of tray: A-PET  
 3. Material of plastic bag: PE-LD





612(pcs)x40(BOX)=24480pcs

	1.44" EPD BOX
N.W. :	1.75Kg
G.W. :	5.19Kg

### Sea / Land / Air Transportation

