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# Product Specifications

<b>Customer</b>	<b>Standard</b>
<b>Description</b>	<b>2.13" 3-Colors TFT EPD Panel</b>
<b>Model Name</b>	<b>E2213FS091</b>
<b>Date</b>	<b>2017/ 10/ 30</b>
<b>Doc. No.</b>	<b>1P166-00</b>
<b>Revision</b>	<b>01</b>

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

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Version	Date	Page (New)	Section	Description
01	2017/10/30	All	All	Product specification first issued.

## 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 3-Colors 2.13" a-Si, active matrix TFT, Electronic Paper Display (EPD) panel. The panel is capable to show Black, White, and Red. The panel has 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)
- Three colors support: White, Black, Red
- Resolution: 212 x 104
- 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	59.2 (H) x 29.2 (V)x 1.1(T)	mm	(1)
Active Area	48.548(H) X 23.712(V)	mm	
Driver Element	a-Si TFT active matrix	-	
FPL	Spectra Red 1.2	-	
Pixel Number	212 x 104	pixel	
Pixel Pitch	0.229 x 0.228 (111dpi)	mm	
Pixel Arrangement	Vertical stripe	-	
Display Colors	Black/ White/ Red	-	
Surface Treatment	Anti-Glare	-	

Note (1): Not including the FPC.

## 1.5 Mechanical Specifications

**Table 1-2 Mechanical Specification**

Item		Min.	Typ.	Max.	Unit	Note
Glass Size	Horizontal(H)	58.9	59.2	59.5	mm	
	Vertical(V)	28.9	29.2	29.5	mm	
	Thickness(T)	1.0	1.1	1.2	mm	(1)
Weight		-	3.2	3.9	g	

Note (1): Not including the Masking Film.

**Table 1-3 FPC Specification**

Item	Pin numbers	Pitch (mm)	Connector	Note
Golden Finger	24	0.5	HRS FH34SRJ 24S or STARCONN 6700S24 or Compatible	

NO.	DESCRIPTION
1	Masking Film
2	Protective Sheet
3	ePaper Film
4	TFT Plate
5	EC Seal

Technical drawing of a display assembly showing a top view and a cross-section A-A.

**Top View Dimensions:**

- Overall Width:  $59.20 \pm 0.2$  (TFT)
- AA Dimension:  $48.548$  (AA)
- BB Dimension:  $29.20 \pm 0.2$  (TFT)
- CC Dimension:  $1.10 \pm 0.1$  (CC)
- Pin-1 and Pin-24 locations are marked.
- Silicon Glue is indicated at the bottom edge.

**Cross-section A-A Details:**

- Layers: 1 (Masking Film), 2 (Protective Sheet), 3 (ePaper Film), 4 (TFT Plate), 5 (EC Seal).
- Stiffener is shown at the bottom.
- Open Finger Side is indicated.
- Dimensions:  $1.20 \pm 0.03$  (Total Thickness),  $0.30 \pm 0.03$  (Stiffener Thickness),  $2.50 \pm 0.3$  (Stiffener Width).

**General tolerance:  $\pm 0.3\text{mm}$**

## 2 Absolute Maximum Ratings

### 2.1 Absolute 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),(4)
Storage Humidity	H <sub>ST</sub>	40	70	% RH	(1),(3),(4)
Operating Ambient Temperature	T <sub>OP</sub>	10	+ 40	°C	(1),(2),(3),(4)
Operating Ambient Humidity	H <sub>OP</sub>	40	70	% RH	(1),(2),(3),(4)
Optimal Storage Temperature	T <sub>OST</sub>	-10	+ 35	°C	(1),(3),(4)
Optimal Storage Humidity	H <sub>OST</sub>	45	65	% RH	(1),(3),(4)

Note (1):

- (a) 70 %RH Max. ( $T_a \leq 40\text{ }^{\circ}\text{C}$ ), 40%RH Min. ( $T_a \leq 60\text{ }^{\circ}\text{C}$ ) where  $T_a$  is ambient temperature.
- (b) No condensation and no frost in absolute ratings of Environment.

Note (2): The temperature of panel display surface area should be 10 °C Min. and 40°C Max. Refresh time depends on operating temperature.

Note (3): Reddish on the edge of black image is normal at high temperature.

Note (4): 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 (5): 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	Note
High Temperature Operation	40 °C/ 30 %RH for 240h	(1) (2)
Low Temperature Operation	10 °C for 240h	(1) (2)
High Temperature/Humidity Operation	40 °C / 70%RH for 240h	(1) (2)
High Temperature Storage	60 °C/ 40 %RH for 240h	(1)(2)(3)
Low Temperature Storage	-20 °C for 240h	(1)(2)(3)
High Temperature/Humidity Storage	50 °C / 80% RH for 240h	(1)(2)(3)
Temperature Shock ( Storage )	-20 °C/30 min ~ 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 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		
Supply Voltage	$V_{DD}, V_{DDIO}$	-0.3	6.0	V	
Ground	GND	-		-	Connect to Ground

$T_a = 25 \pm 2 \text{ }^{\circ}\text{C}$

#### 3.2 Recommended Operation Conditions of Panel

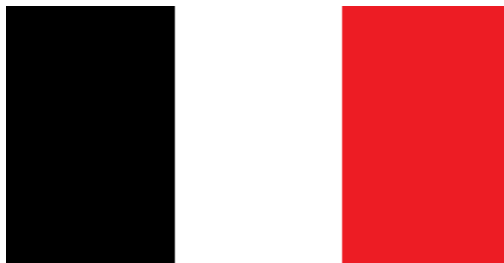
**Table 3-2 DC Characteristics of Panel**

Parameter		Symbol	Value			Unit	Note
			Min	Typ	Max		
Operation voltage		$V_{DD}, V_{DDIO}$	2.3	3.0	3.6	V	
Input Voltage	High	$V_{IH}$	$0.7V_{DDIO}$	-	$V_{DDIO}$	V	
	Low	$V_{IL}$	0	-	$0.3V_{DDIO}$	V	
Output Voltage	High	$V_{OH}$	$V_{DDIO}-0.4$	-	-	V	$V_{DDIO}=V_{DD}$ $I_{OH}=400\mu\text{A}$
	Low	$V_{OL}$	-	-	0.4	V	$V_{DDIO}=V_{DD}$ $I_{OL}=-400\mu\text{A}$ ,
Input Current		$I_{DD}+I_{CC}$	-	TBD	-	mA	(1),(2),(3)

$T_a = 25 \pm 2 \text{ }^{\circ}\text{C}$

Note (1):

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

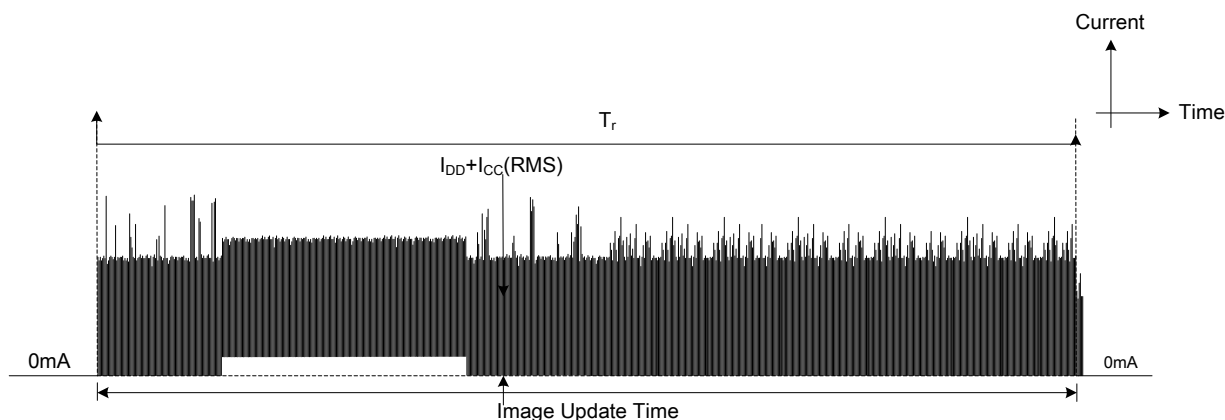


These currents are tested with PDI test jig.

Note (2):

$$V_{DDIO} = V_{DDA} = 3.0V$$

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

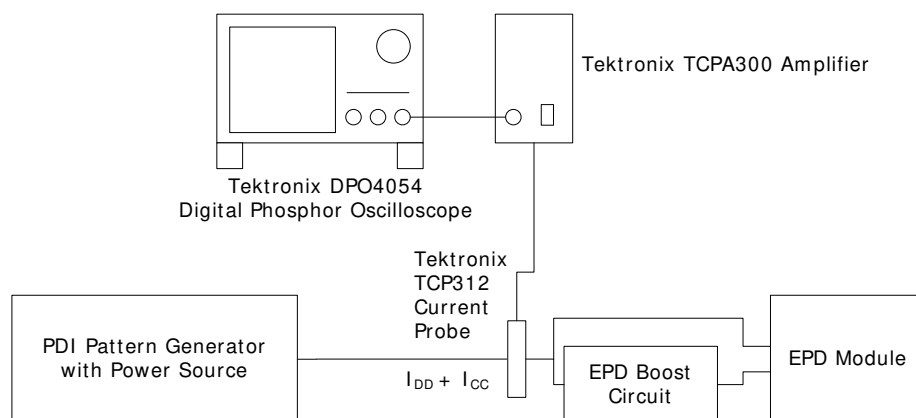


\*  $T_r$ : Refresh time of the image update.

Note (3):  $I_{DD}$ : The current of  $V_{DD} + V_{DDIO}$ .

$I_{CC}$ : The current of  $V_{CC}$  (EPD Boost Circuit).

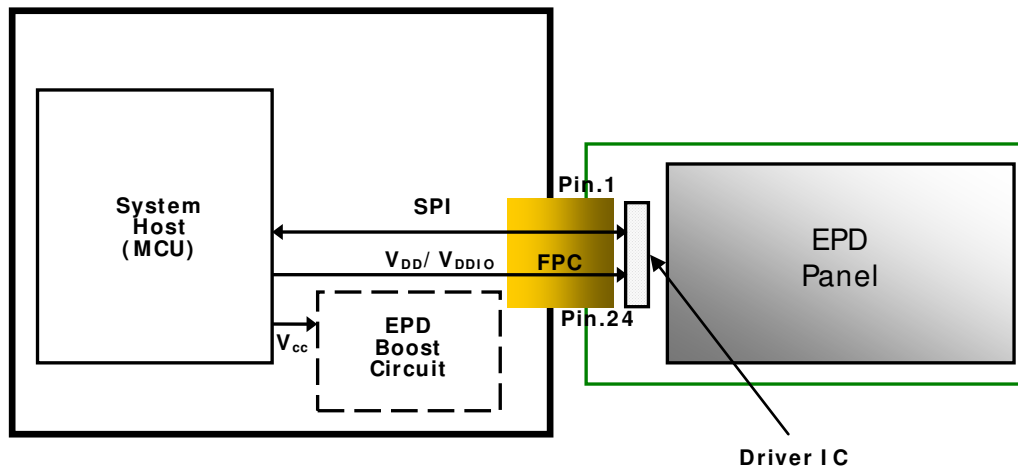
**Figure 3-3 Current Measurement**



\* Set oscilloscope filter to 250MHz and record length to 1M points.

## 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	NC	-	-	Not connected
2	GDR	O	Power MOSFET Driver control	This pin is the N-Channel MOSFET Gate Drive Control.
3	RESE	I	Booster Control Input	This pin is the Current Sense Input for the Control Loop.
4	NC	-	-	Not connected
5	VDHR	C	Capacitor	This pin is the Positive Gate driving voltage and the Power Supply pin for VDHR. A stabilizing capacitor should be connected between VDHR and GND.
6	NC	-	-	-
7	NC	-	-	-
8	BS	I	VSS	This pin is setting panel interface.
9	BUSY_N	O	Device Busy Signal	This pin is Busy state output pin. When Busy is High, the operation of the chip should not be interrupted, and Command should not be sent.
10	RST_N	I	System Reset	This pin is reset signal input. Active Low.
11	D/C	I	VDDIO or VSS	This pin is Data/Command control.
12	CSB	I	VDDIO or VSS	This pin is the chip select.
13	SCL	I	Data Bus	Serial communication clock input.
14	SDA	I	Data Bus	Serial communication data input/output.

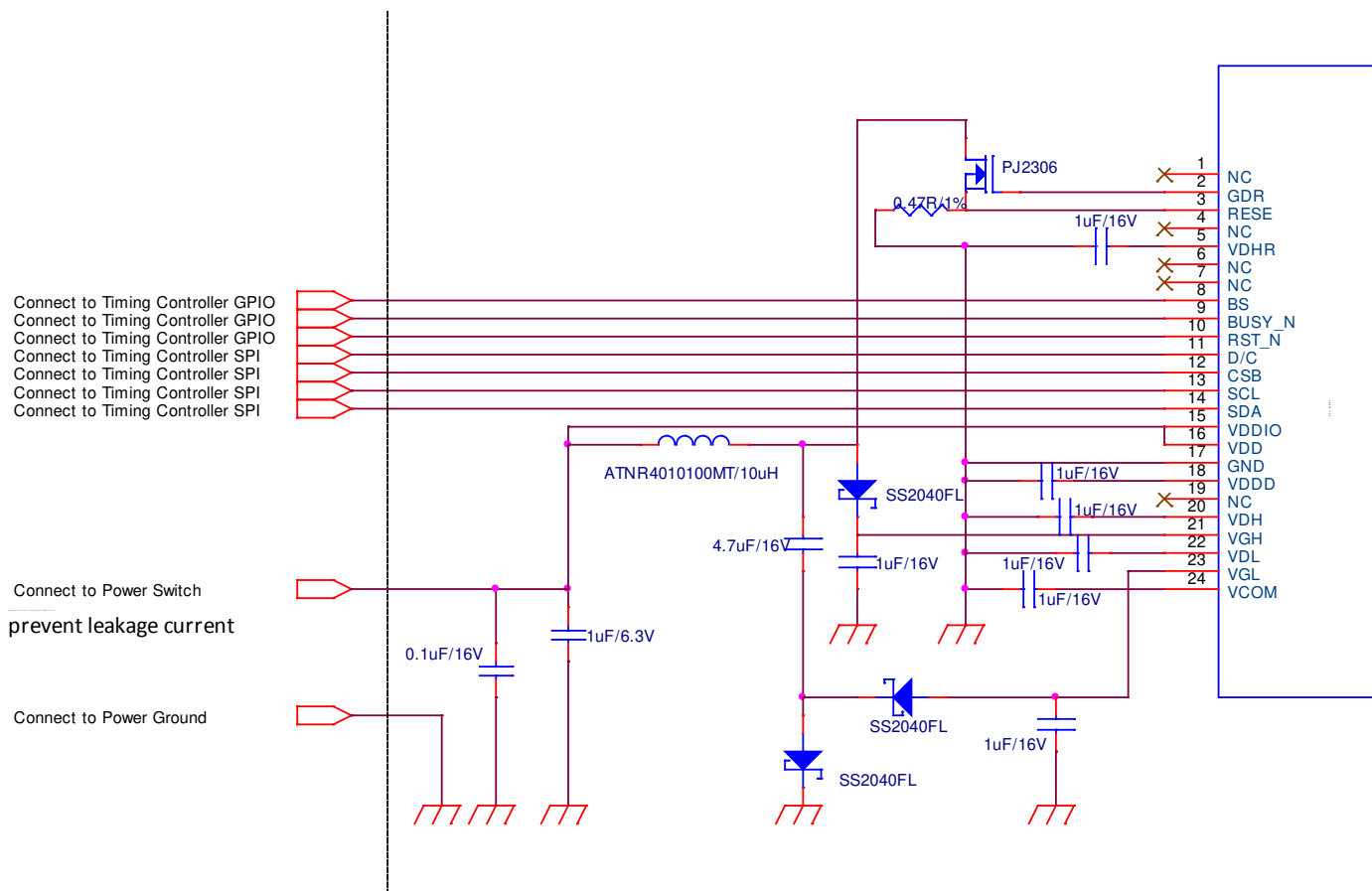
No.	Signal	Type	Connected to	Function
15	VDDIO	P	Power Supply	Power for interface logic pins & I/O. It should be connected with VDDIO.
16	VDD	P	Power Supply	Power Supply for the chip.
17	GND	P	Ground	Ground
18	VDDD	C	Capacitor	Internal regulator output A capacitor should be connected between VDDD and VSS.
19	NC	-	-	-
20	VDH	C	Capacitor	This pin is the Positive Source driving voltage. A stabilizing capacitor should be connected between VSH and GND.
21	VGH	C	Capacitor	A stabilizing capacitor should be connected between VGH and GND.
22	VDL	C	Capacitor	This pin is the Negative Source driving voltage and the Power Supply pin for VCOM. A stabilizing capacitor should be connected between VSL and GND.
23	VGL	C	Capacitor	A stabilizing capacitor should be connected between VGL and GND.
24	VCOM	C	Capacitor	This pin is the VCOM driving voltage A stabilizing capacitor should be connected between VCOM and GND.

Note:

Type: I: Input  
O: Output  
C: Capacitor  
P: Power

## 5.2 Reference Circuit

Figure 5-1 EPD Reference Circuit



Type	Part	Vendor
Inductor	10uH ATNR4010100MT + -20% 0.8A	ARLITECH
Transistor	PJ2306 SOT-23 N-Channel 30V/3.2A	PANJIT
Diode	SS2040FL SOD-123FL	PANJIT



## 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>DD</sub> , V <sub>DDIO</sub> , V <sub>DDA</sub>	3.0	V

Note (1): Image is updated with above condition.

### 6.2 Optical Specifications

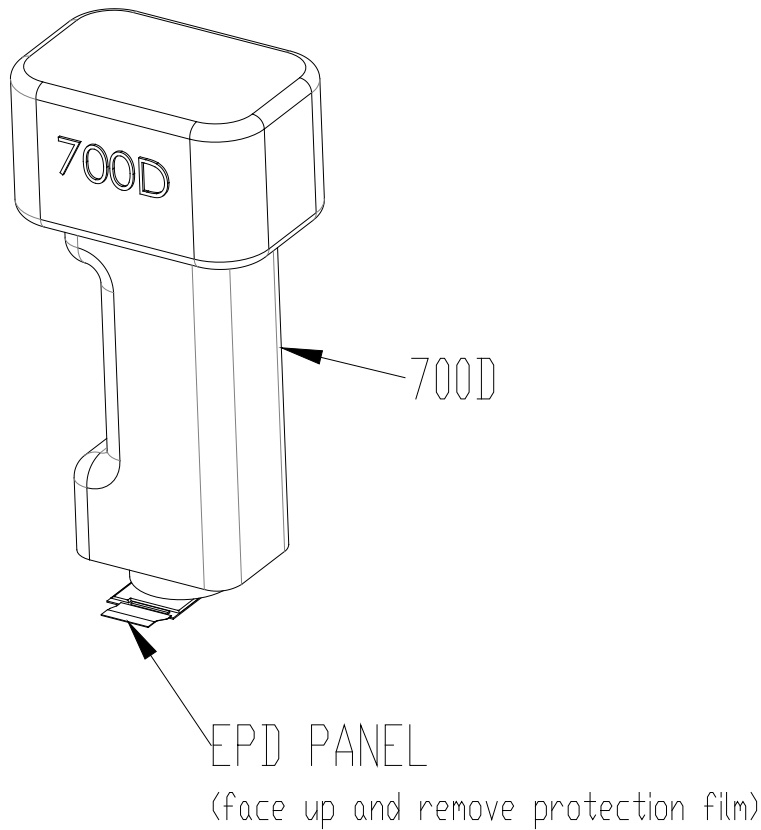
#### 6.2.1 Optical

**Table 6-2 Optical Measurement with D65 Light Source**

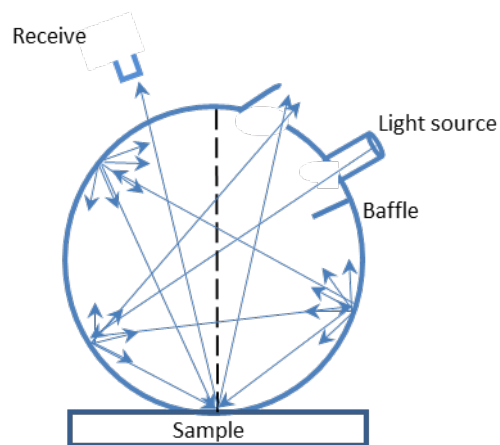
Item	Color	Symbol	Rating			Unit	Note
			Min.	Typ.	Max.		
Contrast ratio	Black/White	CR	-	21:1	-	-	$\theta_x=\theta_y=0$ (1),(2),(5),(6)
Refresh time	Black/White/Red	Tr	-	(15.5)	-	sec	(1),(3),(4),(6)
White state	White	L*	-	72	-	-	$\theta_x=\theta_y=0$ (1),(2),(6)
	White	a*	-	-1.16	-		
	White	b*	-	3.0	-		
Red state	Red	L*	-	30	-	-	$\theta_x=\theta_y=0$ (1),(2),(6)
	Red	a*	-	39.7	-		
	Red	b*	-	18.0	-		
Reflectance	White	R%	-	43	-	%	(1),(2),(6)

Note (1): P 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**

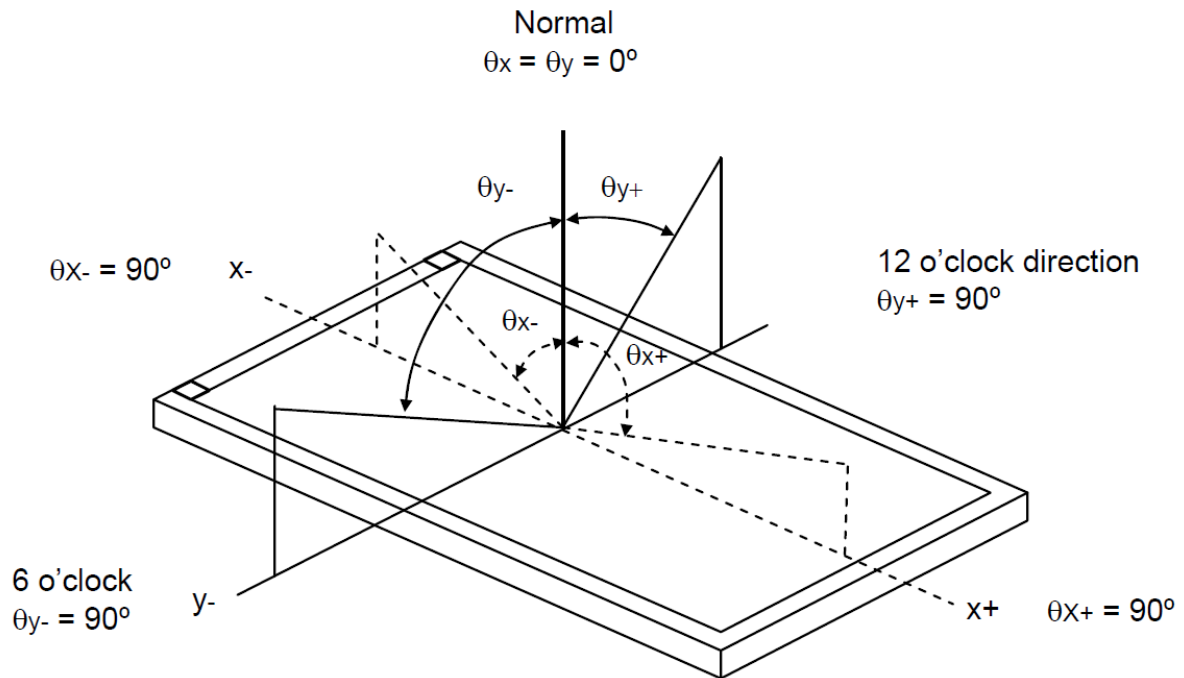


**SCE mode**



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 vary due to different lot of film, display performance requirements, and ambient temperatures.

Note (4):  $T_r$  is the refresh time for an image which has no Red. For an image with Red, Red/White, Red/Black, or Red/Black/White, the total update time is ( $T_r$ ).

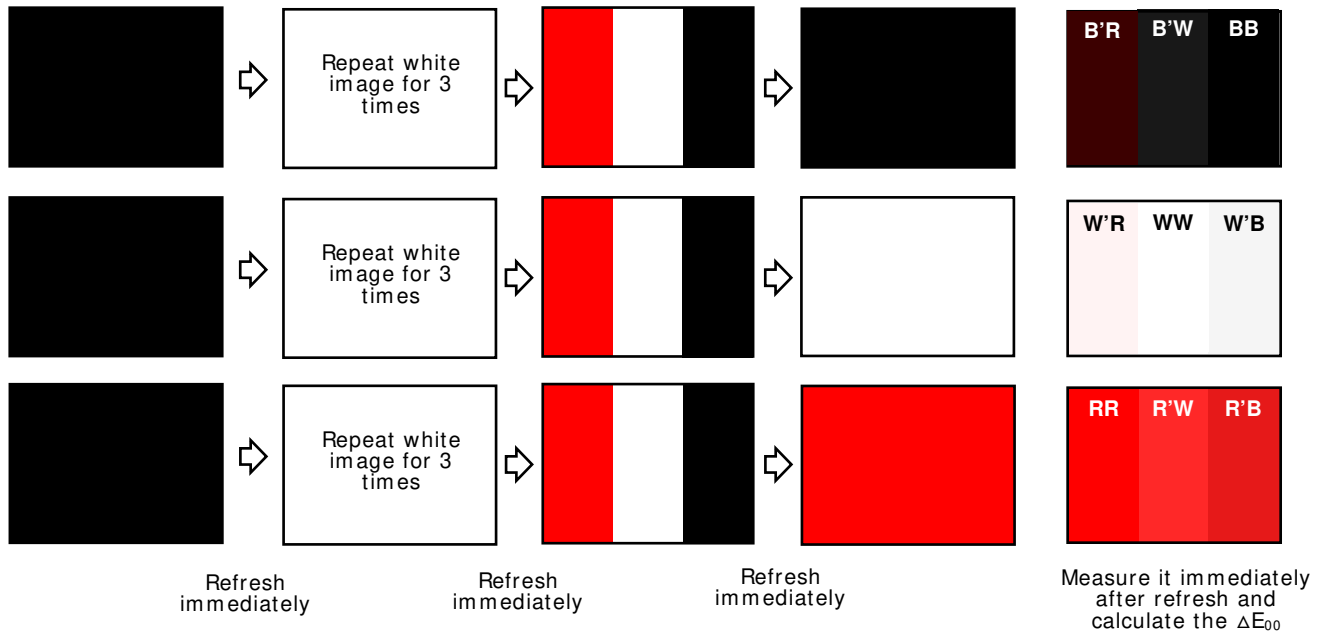
Note (5): Contrast ratio (C.R.): The Contrast ratio is calculated by the following expression.  $C.R. = (R\% \text{ White}) / (R\% \text{ Black})$ .

Note (6): Optical data is measured at 60 seconds after refresh with PDI's global update procedure.

### 6.2.2 Ghosting

Below are test method to verify if ghosting is within an acceptable range. The measured data ( $L^*$ ,  $a^*$ ,  $b^*$ ) to calculate color different,  $\Delta E_{00}$  (CIEDE 2000). The condition of measurement is to follow “ Table 6-1 Optical Measurement Conditions”.

- Ghosting Measurement



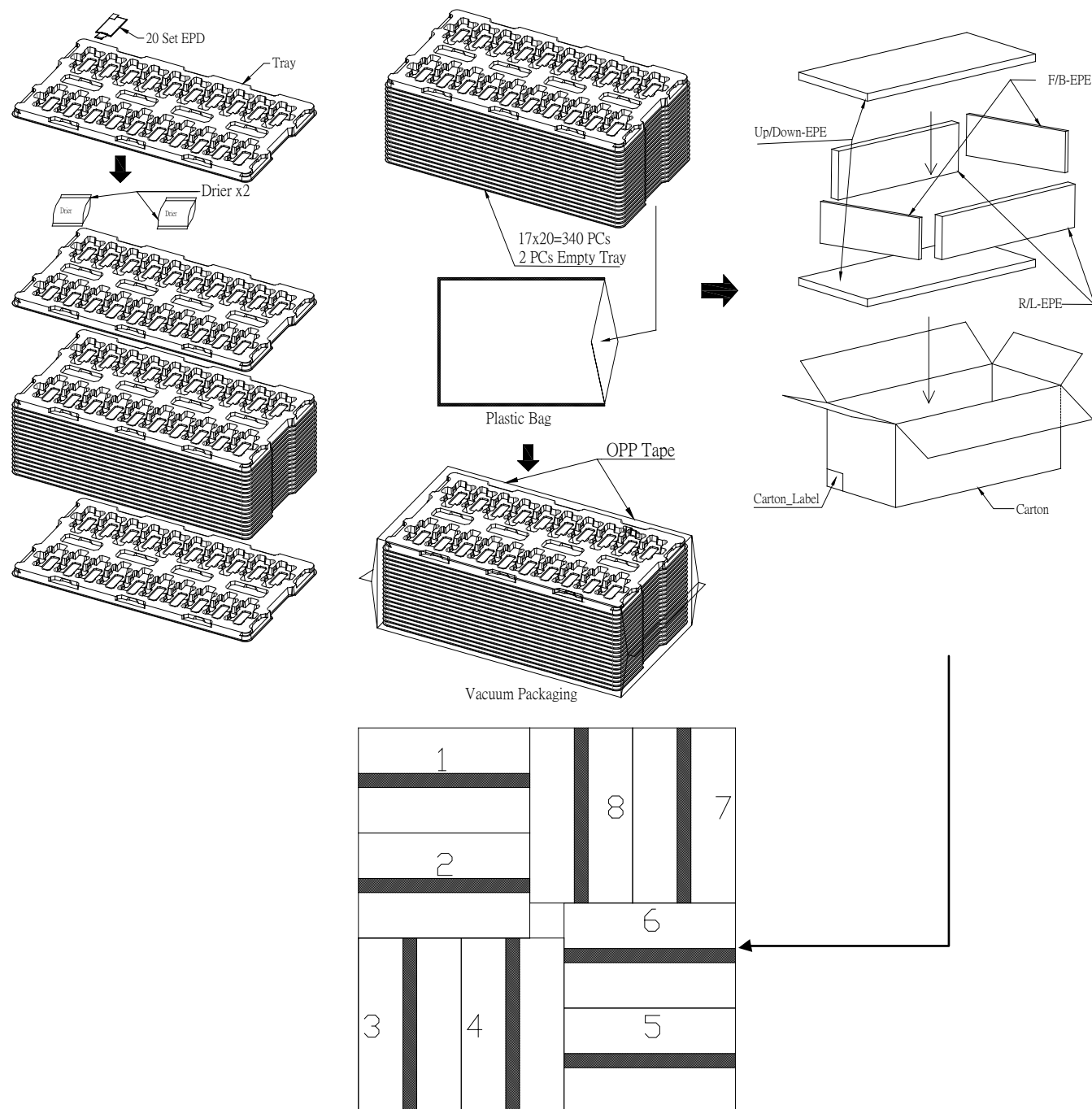
**Table 6-3 Measurement of Ghosting**

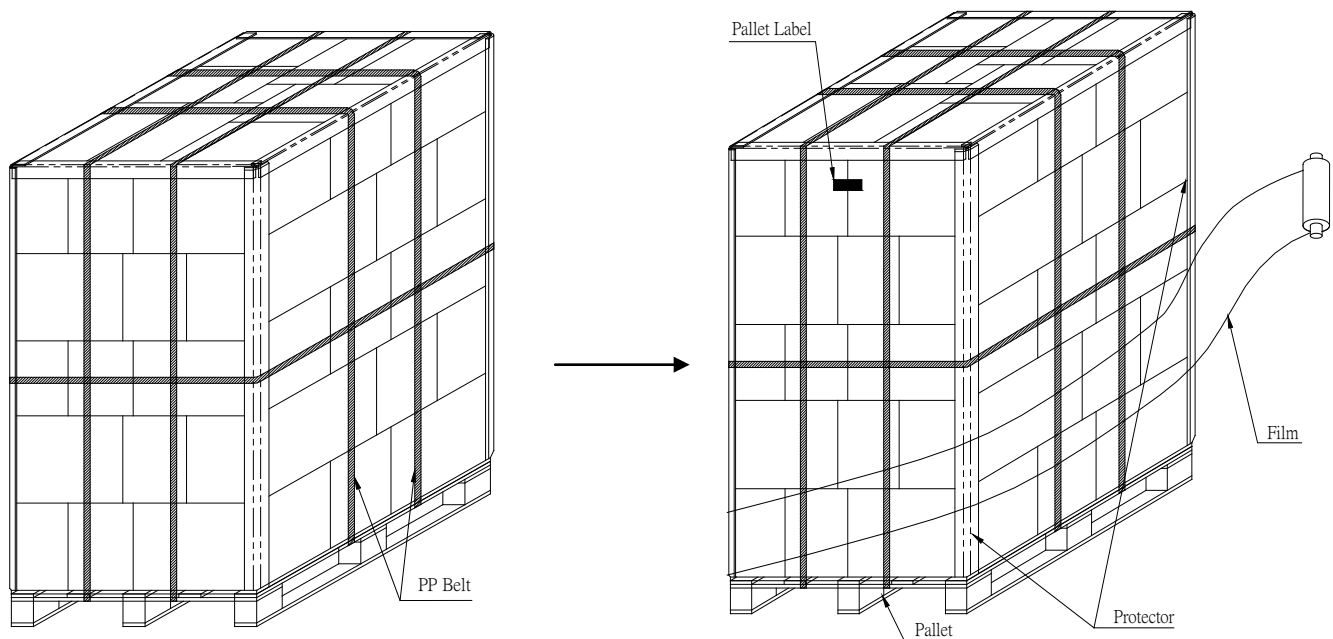
Item	Rating		
	Min.	Typ.	Max.
$B'W\Delta E_{00}$	-	-	2
$W'B\Delta E_{00}$	-	-	2
$R'W\Delta E_{00}$	-	-	TBD
$W'R\Delta E_{00}$	-	-	TBD
$B'R\Delta E_{00}$	-	-	TBD
$R'B\Delta E_{00}$	-	-	TBD

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

## 7 Packing

Figure 7-1 Packing Diagram





340(pcs)x40(BOX)= 13600 pcs

	2.13" EPD BOX
N.W. :	1.09 Kg
G.W. :	4.46 Kg

Sea / Land / Air Transportation

