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Product Specifications

Customer	Standard
Description	2.87" 3-Colors TFT EPD Panel
Model Name	E2287ES051
Date	2016/ 08/ 019
Doc. No.	1P112-00
Revision	01

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

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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
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 2.87" a-Si, active matrix TFT, Electronic Paper Display (EPD) panel. The panel is capable to show Black, White, and Red. It supports breakage detection. The panel has high resolution (112dpi) 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)
- 3-colors support: White, Black, Red
- Breakage Detection
- Resolution: 296 x 128
- 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	79.0(H) x 36.7(V) x 1.0(T)	mm	(1)
Active Area	66.90(H) x 29.06(V)	mm	
Driver Element	a-Si TFT active matrix	-	
FPL	Spectra	-	
Pixel Number	296 x 128	pixel	
Pixel Pitch	0.23 x 0.23 (112dpi)	mm	
Pixel Arrangement	Vertical stripe	-	
Display Colors	Black/White/Red	-	
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)	78.7	79.0	79.3	mm	
	Vertical(V)	36.4	36.7	37.0	mm	
	Thickness(T)	0.9	1.0	1.1	mm	(1)
Weight		-	5.4	6.5	g	

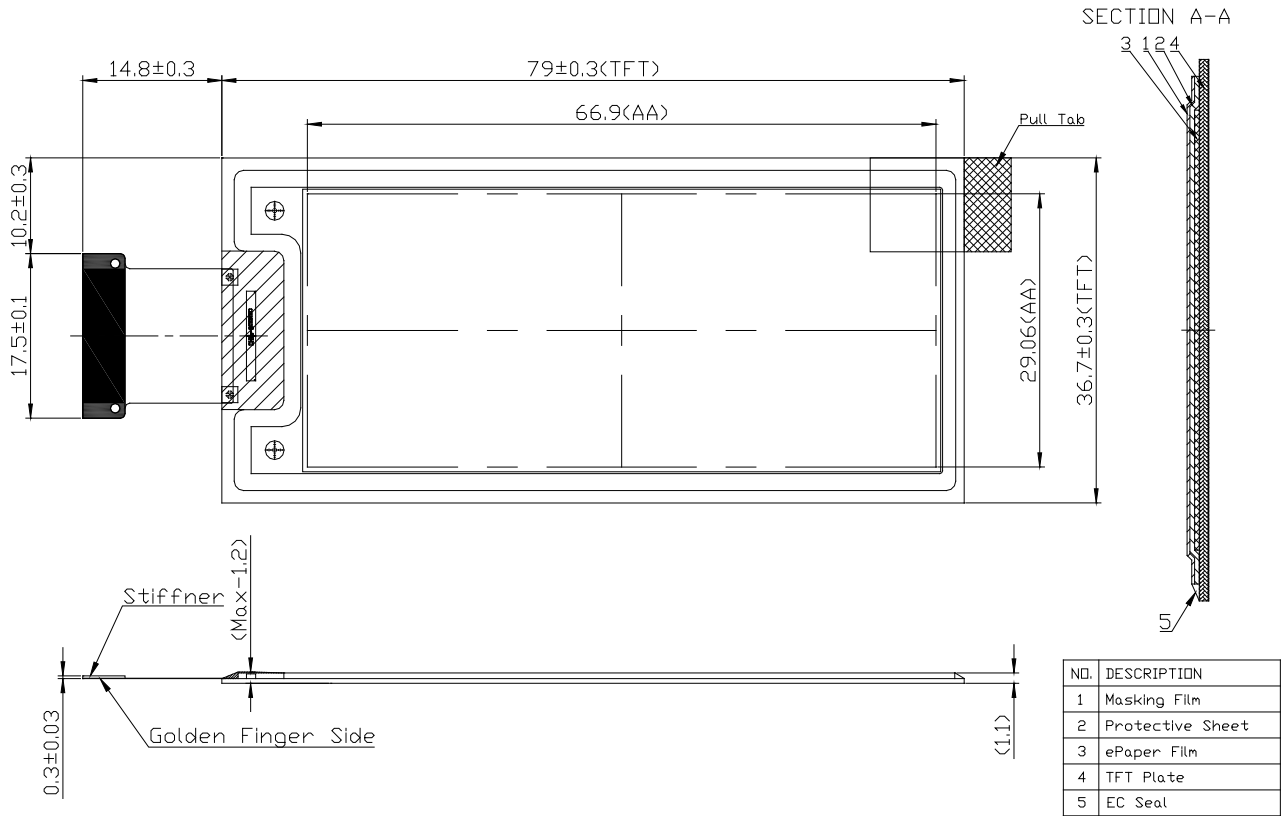
Note (1): Not including the Masking Film.

Table 1-3 Input Connector Specification

Item	Pin numbers	Pitch (mm)	Connector	Note
Golden Finger	26	0.5	HRS FH34SRJ 34S or STARCONN 6700S34 or Compatible	

Note (1): HRS FH34SRJ 34S and STARCONN 6700S34 are 34-pins connectors. The middle 26 pins are used to connect FPC pads of EPD. The other 8 pins are used as dummy pins. Please refer PDI demo kit for detailed connection.

Figure 1-1 EPD Drawing



General tolerance: ± 0.3 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 _{ST}	-20	+ 60	°C	(1),(3),(4)
Storage Humidity	H _{ST}	40	70	%RH	(1),(3),(4)
Operating Ambient Temperature	T _{OP}	10	+ 40	°C	(1),(2),(3),(4)
Operating Ambient Humidity	H _{OP}	40	70	%RH	(1),(2),(3),(4)
Optimal Storage Temperature	T _{ST}	-10	+ 35	°C	(1),(3),(4)
Optimal Storage Humidity	H _{ST}	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		
Logic 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

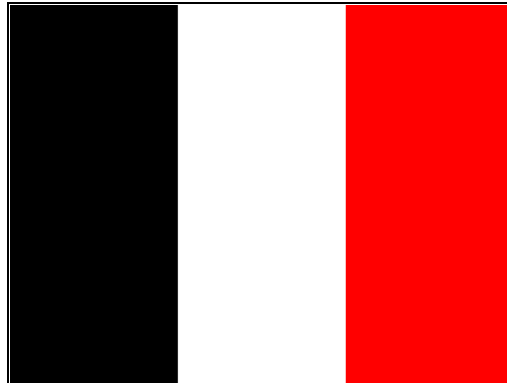
Table 3-2 DC Characteristics of Panel

Parameter	Symbol	Value			Unit	Note	
		Min	Typ	Max			
Operation voltage	$V_{CC}, V_{DD}, V_{DDIO}, V_{DDA}$	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	$I_{DD}+I_{CC}$	-	8	-	mA	(1),(2),(3)	

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

Note (1):

Figure 3-1 Test Pattern of Panel

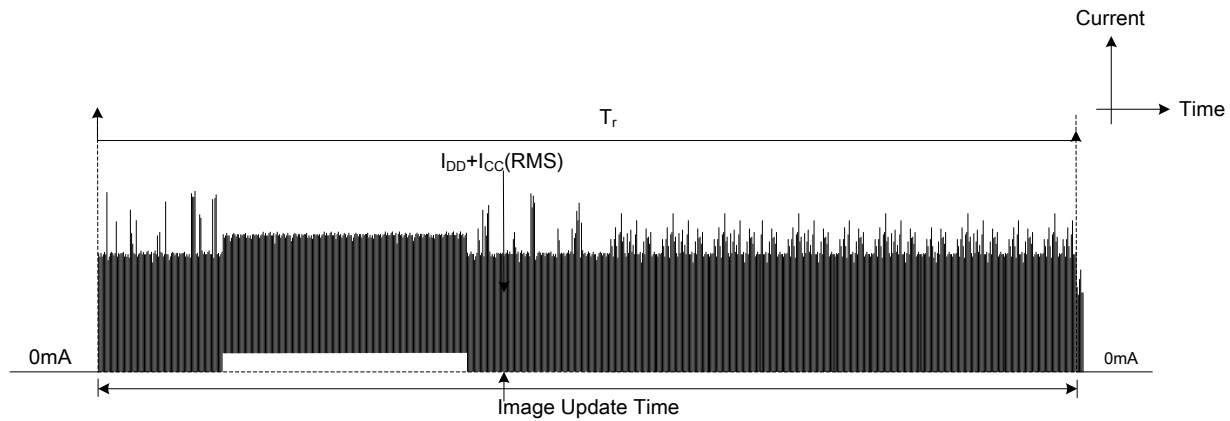


These currents are tested with PDI test jig.

Note (2):

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

Figure 3-2 Image Update Current Profile

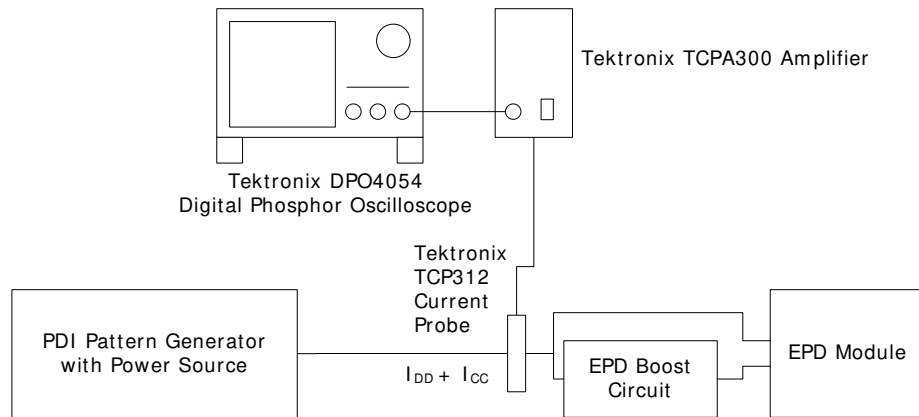


* T_r : Refresh time of the image update.

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

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

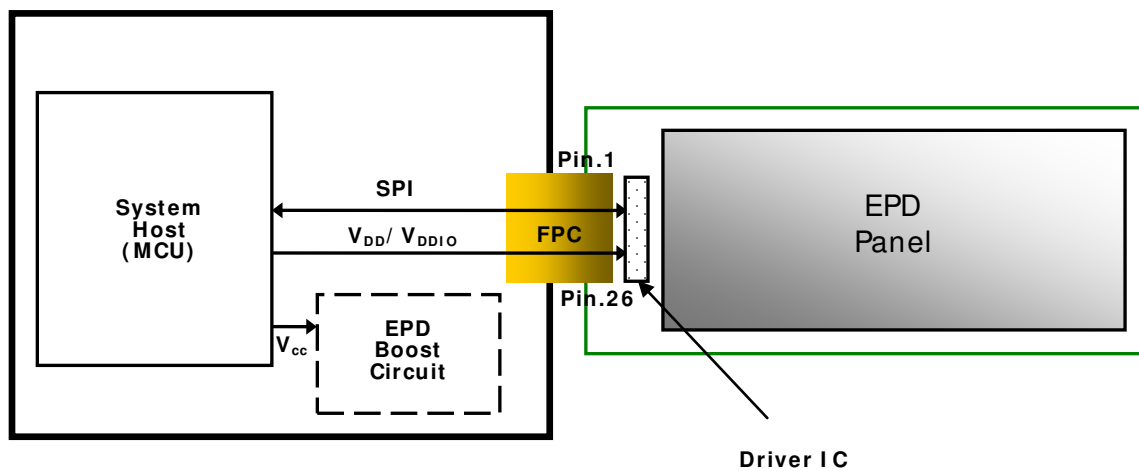
Figure 3-3 Current Measurement



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

4 Application Circuit Block Diagram

4.1 Application Circuit Block Diagram



5 Terminal Pin Assignment

5.1 Input Terminal Pin Assignment

Table 5-1 Terminal Pin Assignment

No.	Signal	Type	Connected to	Function
1	GUARD1	O	System I/O	Glass Breakage Detection H: Normal L: Broken
2	NC	-	-	-
3	GDR	O	Power MOSFET Driver Control	This pin is the N-Channel MOSFET Gate Drive Control.
4	RESE	I	Booster Control Input	This pin is the Current Sense Input for the Control Loop.
5	NC	-	-	-
6	VDHR	C	Capacitor	This pin is the positive source driving voltage for red. A stabilizing capacitor should be connected between VDHR and GND.
7	NC	-	-	Not connected
8	NC	-	-	Not connected
9	BS	I	Ground	This pin is setting panel interface.
10	BUSY_N	O	Device Busy Signal	This pin is Busy state output pin. L: Driver is busy, data/command is transforming. H: Host side can send command/data to driver
11	RST_N	I	System Reset	This pin is reset signal input. Active Low.
12	DC	I	Serial Bus	This pin is Data/Command control. L: command H: data
13	CSB	I	Serial Bus	This pin is the chip select.
14	SCL	I	Serial Bus	Serial communication clock input

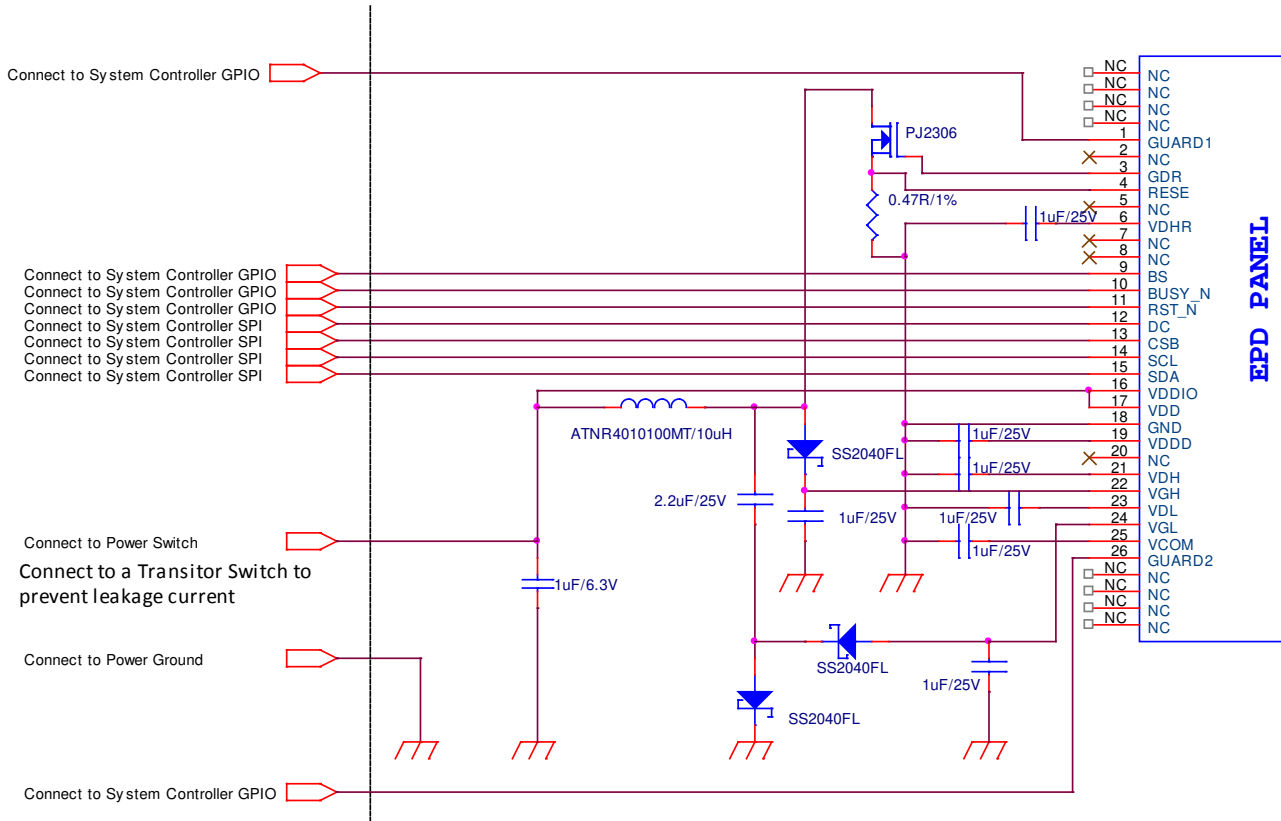
No.	Signal	Type	Connected to	Function
15	SDA	I/O	Serial Bus	Serial communication data input
16	VDDIO	P	Power Supply	Power supply for interface logic pins & I/O.
17	VDD	P	Power Supply	Power supply for digital.
18	GND	P	Ground	-
19	VDDD	P	Capacitor	This pin is the internal LDO(1.8V)
20	NC	-	-	-
21	VDH	C	Capacitor	This pin is the positive source driving voltage. A stabilizing capacitor should be connected between VDH and GND.
22	VGH	C	Capacitor	This pin is the positive gate driving voltage. A stabilizing capacitor should be connected between VGH and GND.
23	VDL	C	Capacitor	This pin is the negative source driving voltage. A stabilizing capacitor should be connected between VDL and GND
24	VGL	C	Capacitor	This pin is the negative gate driving voltage. A stabilizing capacitor should be connected between VGL and GND.
25	VCOM	C	Capacitor	This pin is the VCOM driving voltage A stabilizing capacitor should be connected between VCOM and GND.
26	GUARD2	O	System I/O	Glass Breakage Detection H: Normal L: Broken

Note:

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

5.2 Reference Circuit

Figure 5-1 EPD Reference Circuit



Note (1): HRS FH34SRJ 34S and STARCONN 6700S34 are 34-pins connectors. The middle 26 pins are used to connect FPC pads of EPD. The other 8 pins are used as dummy pins.

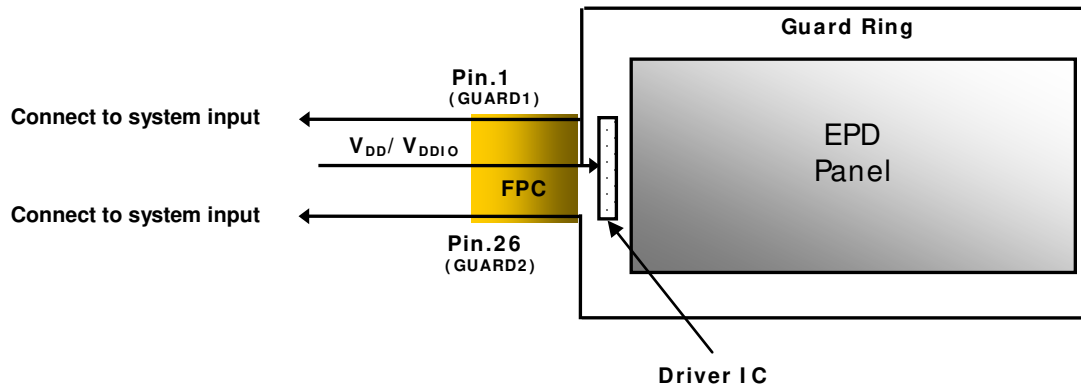
Type	Part	Vendor
Inductor	10uH ATNR4010100MT + -20% 0.8A H= 0.9mm	ARLITECH
Transistor	PJ2306 SOT-23 N-Channel 30V/3.2A	PANJIT
Diode	SS2040FL SOD-123FL	PANJIT

Note:

- (1) PJ2306 is a N-Channel Power MOSFET. The specification of selection criteria are $R_{DS} < 100$ mohm (the lower the better), $V_{DSS} = 30V$, $V_{GS-th} < 2.5V@250uA$.
- (2) SS2040FL is a Schottky diode needs the V_f as lower as possible, 0.2 to 0.4V and the repetitive peak reverse voltage $> 25V$.

5.3 Glass Breakage Detection

Breakage detection is a new feature that can let user know whether the glass substrate is broken. Before update, the system controller can check the signal on Guard Ring (Guard1 and Guard2). If this signal is not V_{DDIO} , the glass is possibly broken. In this case, the EPD may be not able to display image correctly. This feature is very critical for the bi-stable displays.



Note (1) : If there is not enough system controller GPIO. Using pin 26 of FPC can have larger coverage to detect breakage.

Note (2): The GPIOs must add a resistor to ground when the GPIO don't have the internal resistor to ground.

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 _{DD} , V _{DDIO} , V _{DDA}	3.0	V

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

6.2 Optical Specification

6.2.1 Optical

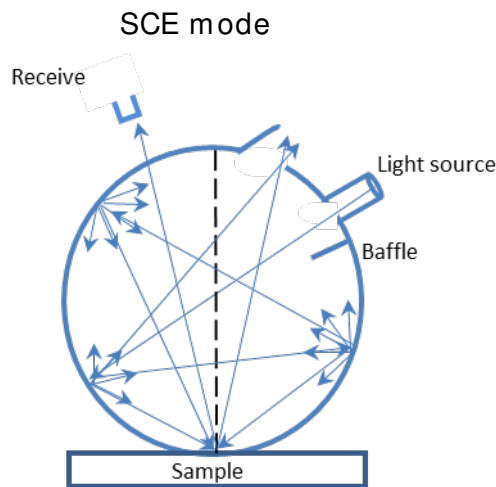
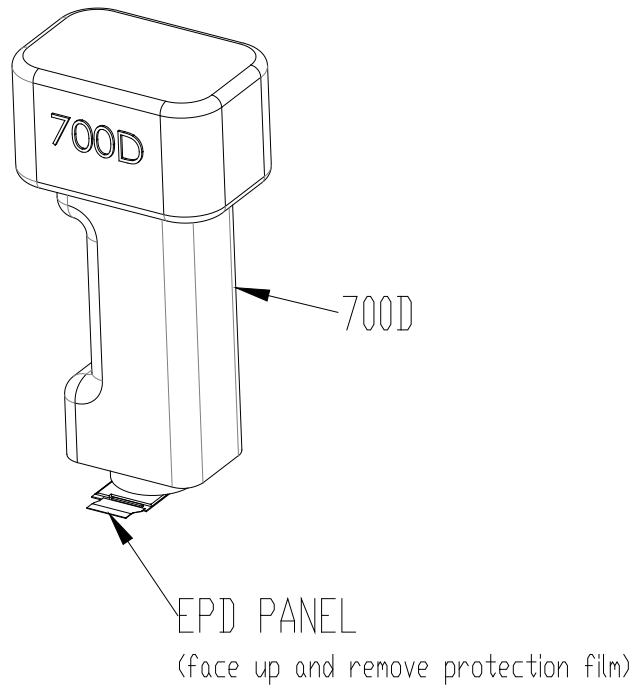
Table 6-2 Optical Measurement with D65 Light Source

Item	Color	Symbol	Rating			Unit	Note
			Min.	Typ.	Max.		
Contrast ratio	Black/White	CR	-	22:1	-	-	$\theta_x=\theta_y=0$ (1),(2),(5),(6)
Refresh time	Black/White/Red	Tr	-	11	-	sec	(3),(4),(6)
White state	White	L*	-	70	-	-	$\theta_x=\theta_y=0$ (1),(2),(6)
	White	a*		0			
	White	b*	-	5.0	-		
Red state	Red	L*	-	27.7	-	-	$\theta_x=\theta_y=0$ (1),(2),(6)
	Red	a*		38.7			

	Red	b*	-	22.2	-		
Reflectance	White	R%	-	41	-	%	(1),(2),(6)

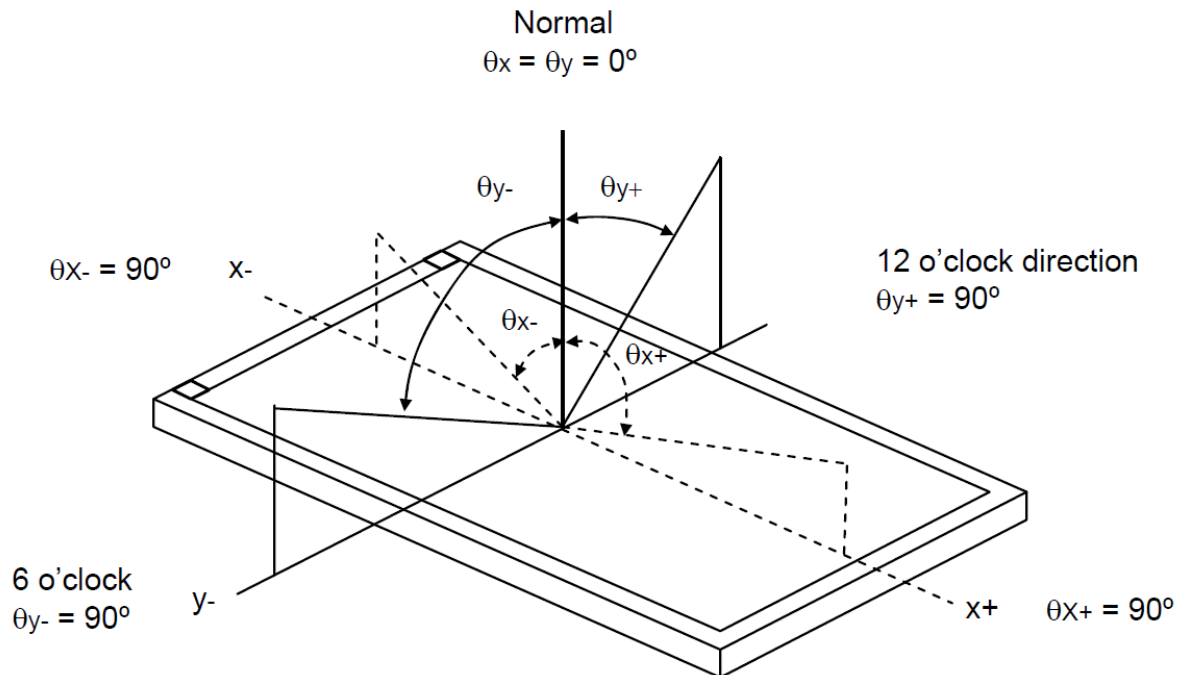
Note (1): Panel is driven by PDI waveform without masking film and optical measurement by CM-700D with D65 light source and SCE mode.

Figure 6-1 Optical Measurement



Note (2): Definition of Viewing Angle (θ_x , θ_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 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, ΔE_{00} (CIEDE 2000).

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

- Ghosting Measurement

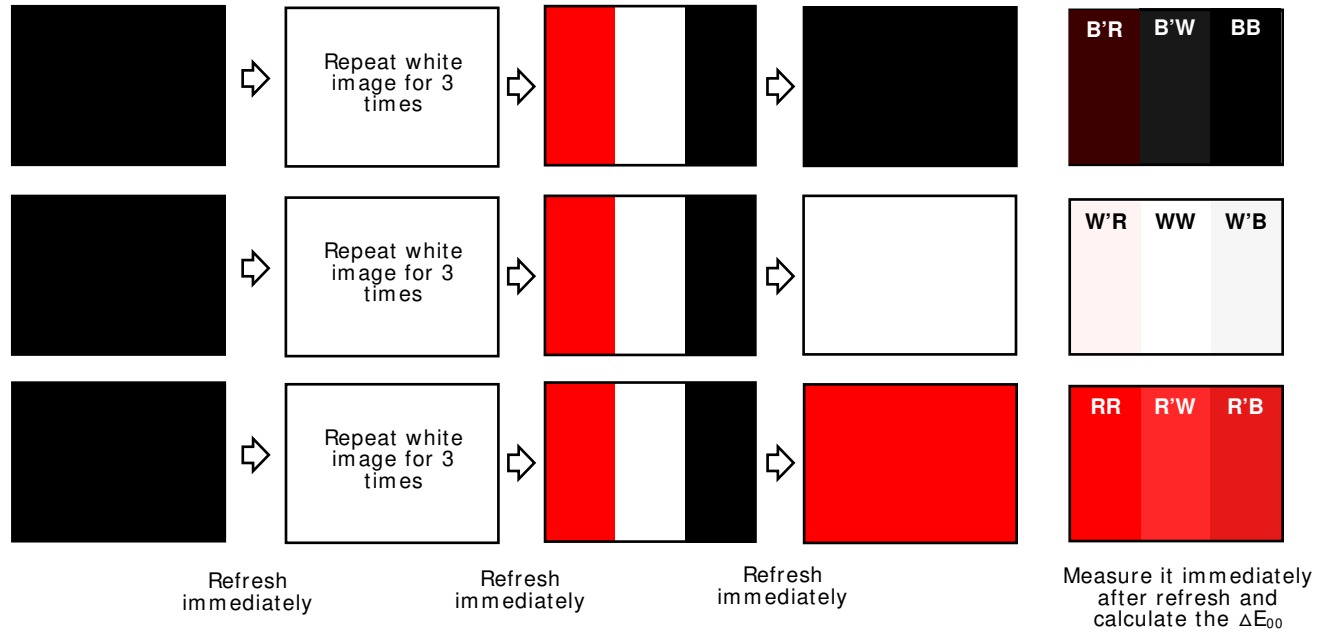


Table 6-3 Measurement of Ghosting

Item	Rating		
	Min.	Typ.	Max.
B'W ΔE_{00}	-	-	2
W'B ΔE_{00}	-	-	2
R'W ΔE_{00}	-	-	TBD
W'R ΔE_{00}	-	-	TBD
B'R ΔE_{00}	-	-	TBD
R'B ΔE_{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.