1. 적용 범위

본 규격은 3.5” Transflective type hVGA용 TFT(Thin Film Transistor) LCD 인 LH350H01-FD01-A41 MODEL의 제품 규격에 관하여 규정한 것이다.

Block Diagram

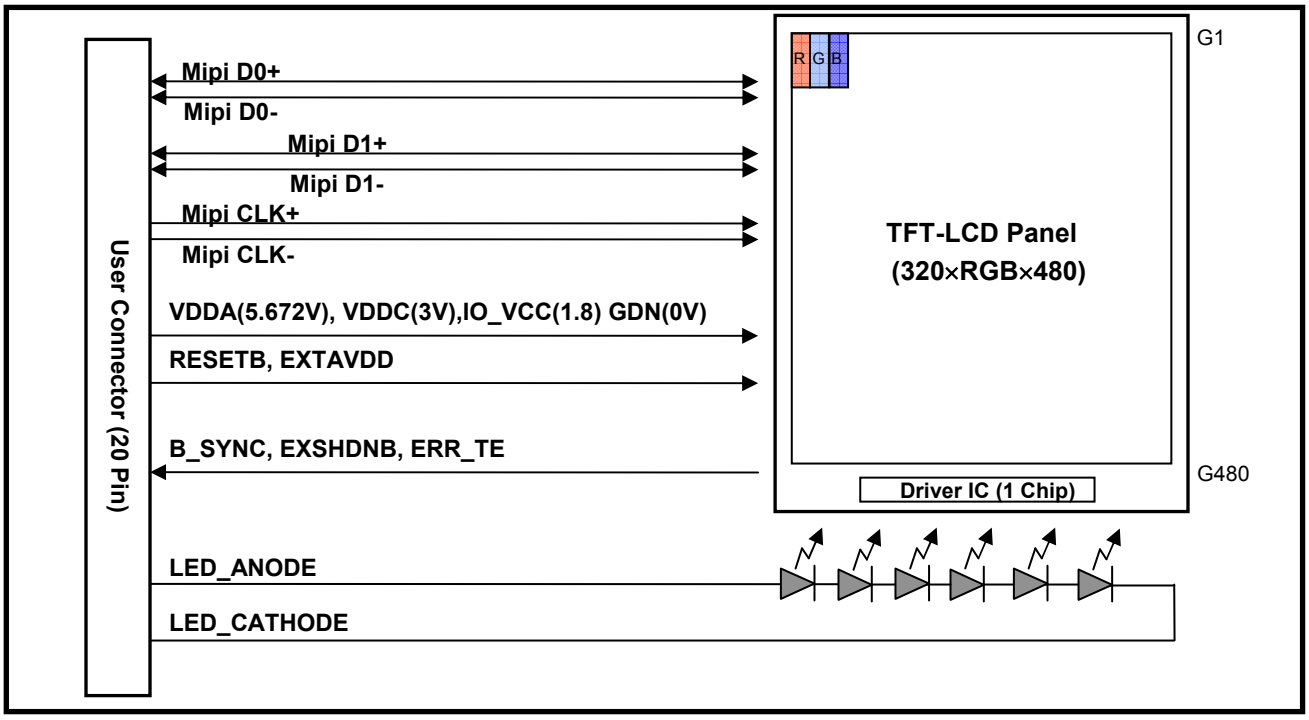


그림1-1. Block Diagram

2. 일반 사양

1) 대각 크기 : 3.54” diagonal
2) 표시 영역[mm] : 49.92(H) × 74.88(V)
3) 화소 수 : 320(H) ×RGB x 480 (V), RGB stripe arrangement
4) 화소 피치[mm] : 0.156(H) × 0.156(V)
5) 모듈 크기[mm] : 55.14 (H) x 82.84 (V) x 1.65 (T) Typ.
6) 표시 모드 : Transflective
7) 주시야각 : 7:30 o’clock (Non-inversion 방향)
8) 모듈 무게 : 15 g[Typ.]
9) 백라이트 : 6 LED
10) 인터페이스 : MIPI
11) 소비 전력[mW] : 470mW (max. B/L on), 55mW (max. B/L off)

3. 절대 정격 사양

Table 3-1. Absolute Maximum Ratings

Parameter	Symbol	Ratings	Units	Notes
LCD Supply Voltage	VDDC	-0.3 ~ +4.0	V	
Switcher Supply Voltage	VDDA	-0.3 ~ +6.4	V	
Logic I/O Voltage	IO_VCC	-0.3 ~ +2.5	V	
Logic Input Voltage	V_{IN}	-0.3 < V_{DI} < V_{EE} +0.3	V	1
LED Power Consumption	P_{LED}	120	mW	2
LED Current	I_{LED}	35	mA	2
Operating Temperature	T_{OP}	-20 ~ +70	°C	3
Storage Temperature	T_{STG}	-30 ~ +80	°C	3
Humidity	H	5% ~ 95%	RH	3
Maximum Pressure		100	N	4

(1) Applies to RESETB, ERR_TE, EXTAVDD, and EXSHDNB.
(2) Applies for each LED individually
(3) Humidity: 95% RH Max, non-condensing > 40°C
(4) Test with a 10 mm diameter metal cylinder with thin rubber tip moving down at 1mm/minute in the center and top left corner without permanent optical change.

※ LED에 흐르는 전류는 그림1을 만족하는 조건으로 설정해야 한다.

■ Ambient Temperature vs. Allowable Forward Current

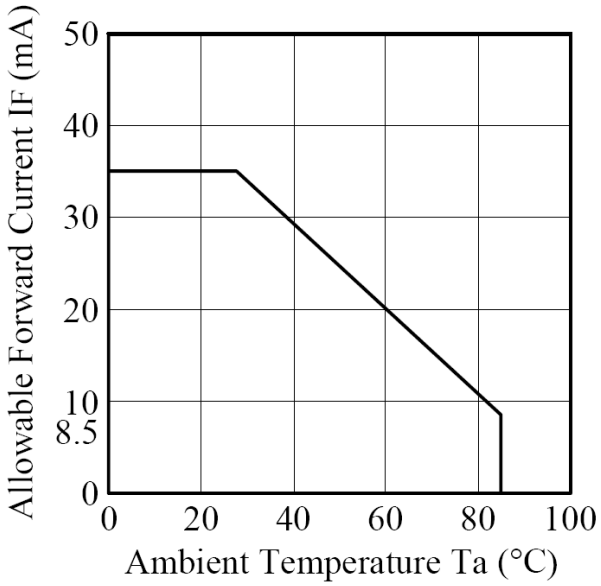


그림3-1. 온도에 대한 LED 최대 허용 전류

4. 전기적 특성 규격

4.1 LCM의 전기적 특성

Table 4-1. Electrical Characteristics

Parameter	Symbol	Values			Units	Notes
		Min	Typ	Max		
LCD Supply Voltage	VDDC - V_{ss}	2.85	3.0	3.15	V	
Switcher Input Voltage	VDDA - V_{ss}	5.468	5.672	5.875	V	
Logic I/O Voltage	IO_VCC - V_{ss}	1.65	1.8	1.95	V	2
Switcher Input Current		-	-	20	mA	1
3.0V Input Current		-	-	8	mA	1
1.8V Input Current		-	-	8	mA	1
LED Input Current	I_{LED}	-	20	25	mA	
"H" Level Input Voltage	V_{IH}	0.8V_{EE}	-	-	V	1,2
"L" Level Input Voltage	V_{IL}	-	-	0.2V_{EE}	V	1,2
"H" Level Output Voltage	V_{OH}	0.8V_{EE}	-	-	V	1,2
"L" Level Output Voltage	V_{OL}	-	-	0.2V_{EE}	V	1,2
Driver Power Supply Stability				250	ms	5
Power, MIPI full refresh	P_{MIPI}	-	45	55	mW	1
Power Consumption, Backlight	P_B	-	384	420	mW	3
Power Consumption, Suspend	P_S	-	-	60	μW	4

(1) The specified current and power consumption are under the conditions at VDDA = V_{DD} = 5.83V, VDDC = 3.0V, IO_VCC = V_{EE} = 1.8 V, T = 25ºC, and f_v = 60 Hz, large black/white checker pattern (20 pixel blocks).
(2) Input mode of RESETB, ERR_TE, EXTAVDD, and EXSHDNB.
(3) LED Backlight assumptions: 3.2 V_f, 20 mA, 6 LED's.
(4) VDDC present only, display off, reset asserted.
(5) Time from VDDC, VDDA and IO_VCC applied until driver power supplies are stable.

4.2 User Interface Pin구성

Table 4-2. Pin Connections

	Signal	I/O	Description	Comment
1	GND	-	Ground	
2	LED-	-	LED Cathode	
3	D0-	I/O	MIPI Data	
4	LED+	-	LED Anode	
5	D0+	I/O	MIPI Data	
6	VDDA	-	6V Switching Power Supply	
7	GND	-	Ground	
8	VDDC	-	3V LCD Power Supply	
9	CLK-	I	MIPI Clock	
10	IO_VCC	-	1.8V LCD Power Supply	
11	CLK+	I	MIPI Clock	
12	RESETB	I	Reset	
13	GND	-	Ground	
14	ERR_TE	O	Error Test	
15	D1-	I/O	MIPI Data	
16	B_SYNC	O	Blanking Sychronization Signal	
17	D1+	I/O	MIPI Data	
18	EXSHDNB	O	System PMU Control Enable	
19	GND	-	Ground	
20	EXTAVDD	I	PMU Configuration	

4.3 Block Diagram & Data Trasfer

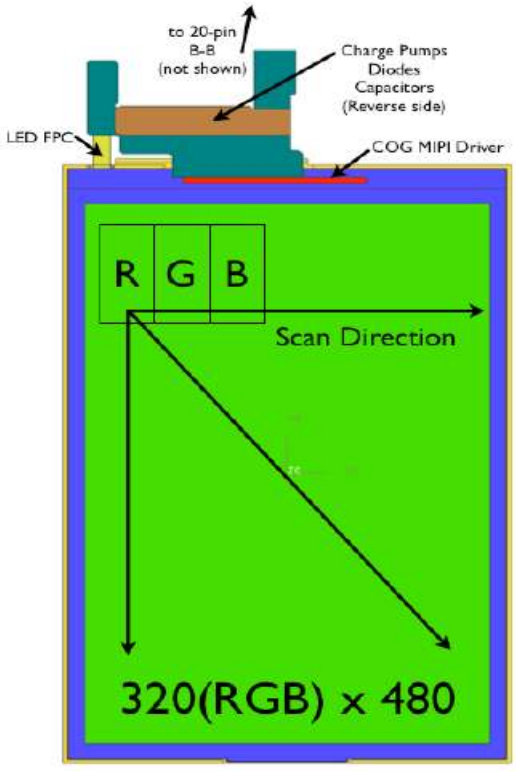


그림4-1. Display Block Diagram

4.4 Interface Timing규격

Table 4-3. Interface Timing Characteristics

Item	Symbol	Timing	Unit	Notes
Vertical cycle	VP	500	Line	1
Vertical low pulse width	VS	8	Line	1
Vertical front porch	VFP	6	Line	1
Vertical back porch	VBP	6	Line	1
Vertical display area	VDISP	480	Line	1
Horizontal cycle	HP	380	clk	1
Horizontal low pulse width	HS	16	clk	1
Horizontal front porch	HFP	12	clk	1
Horizontal back porch	HBP	12	clk	1
Horizontal display area	HDISP	320	clk	1
Pixel Clock	fPCLK	10.80	MHz	1,2
	tPCLK	92.5925925	ns	1

Note 1: VDDC = 2.85~3.15V, IO_VCC = V_{EE}=1.65~1.95V
Note 2: Use 10.80MHz for Vcom & Gamma adjustment.

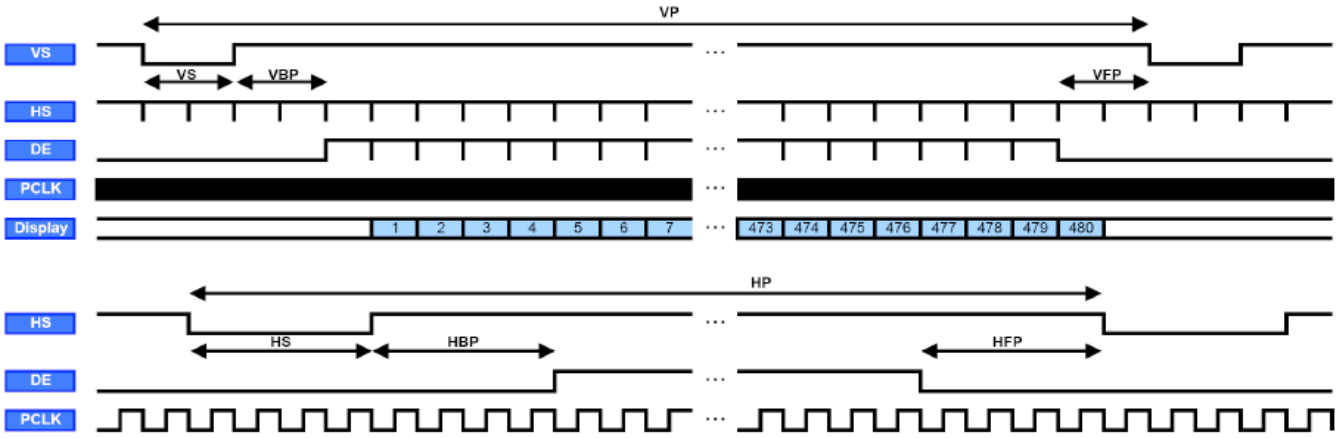


그림4-2. Timing Characteristics

4.5 표시색상과 입력 데이터 기준

Table 4-4. Color vs. Data

Colors & Gray Scale	Gray scale Levels	Data Signal																							
		R0	R1	R2	R3	R4	R5	R6	R7	G0	G1	G2	G3	G4	G5	G6	G7	B0	B1	B2	B3	B4	B5	B6	B7
Black	--	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blue	--	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
Green	--	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
Cyan	--	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Red	--	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Magenta	--	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
Yellow	--	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
White	--	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Black	GS0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
⇑ Darker ⇑ ⇓ Brighter ⇓	GS1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	GS2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	↓	↓																							
	↓	↓																							
	GS61	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	GS62	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Red	GS63	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Black	GS0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
⇑ Darker ⇑ ⇓ Brighter ⇓	GS1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	GS2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	↓	↓																							
	↓	↓																							
	GS61	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0
	GS62	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
Green	GS63	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
Black	GS0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
⇑ Darker ⇑ ⇓ Brighter ⇓	GS1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	GS2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	↓	↓																							
	↓	↓																							
	GS61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1
	GS62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Blue	GS63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1

4.6 Power On/off Sequence

비정상적인 화면 표시 방지 및 최적의 화면을 구현하기 위해서는 아래의 Timing Flowchart를 반드시 지켜야 한다.

Power On Sequence

Power to VDDC is switched on after or simultaneously with Vdd.

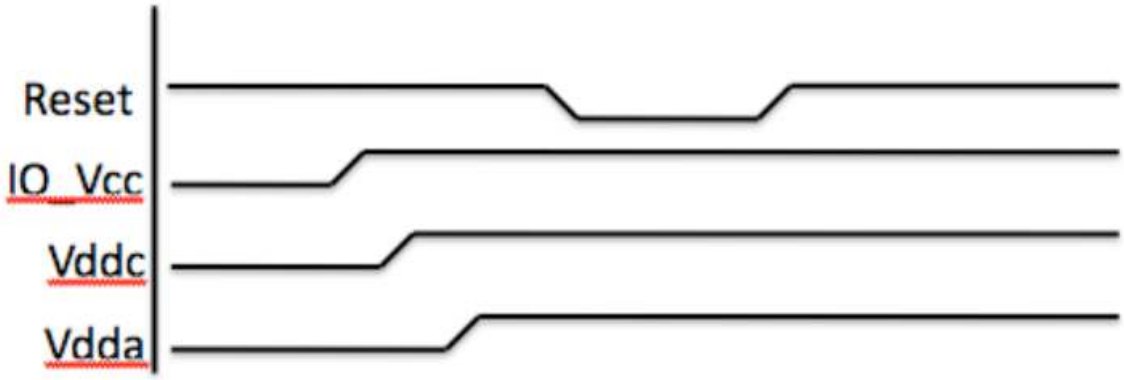


그림4-3. Power on Sequence

Power Off Sequence

Power to VDDC is removed.
In a normal power off sequence the commands and/or register settings are followed.

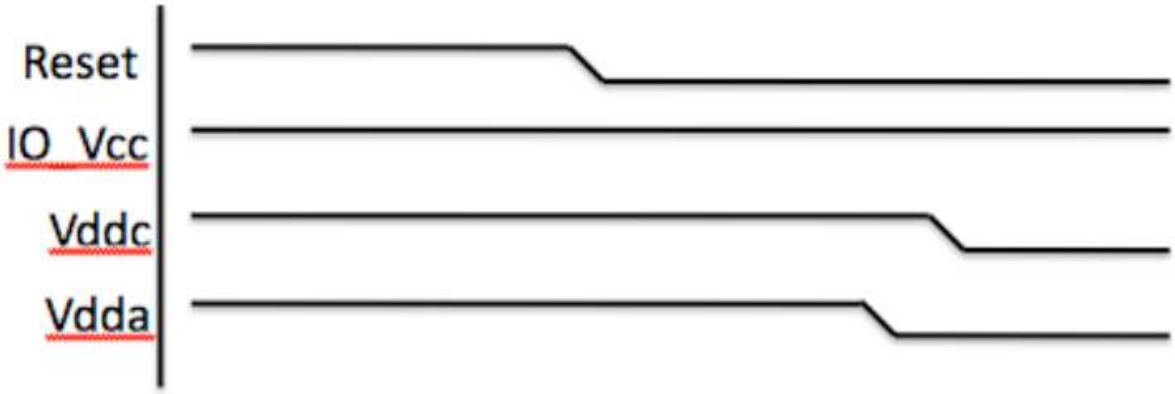


그림4-4. Power off Sequence

Hard Reset

Under a hard reset condition, power to VDDC and IO_VCC are cut simultaneously during display operation.

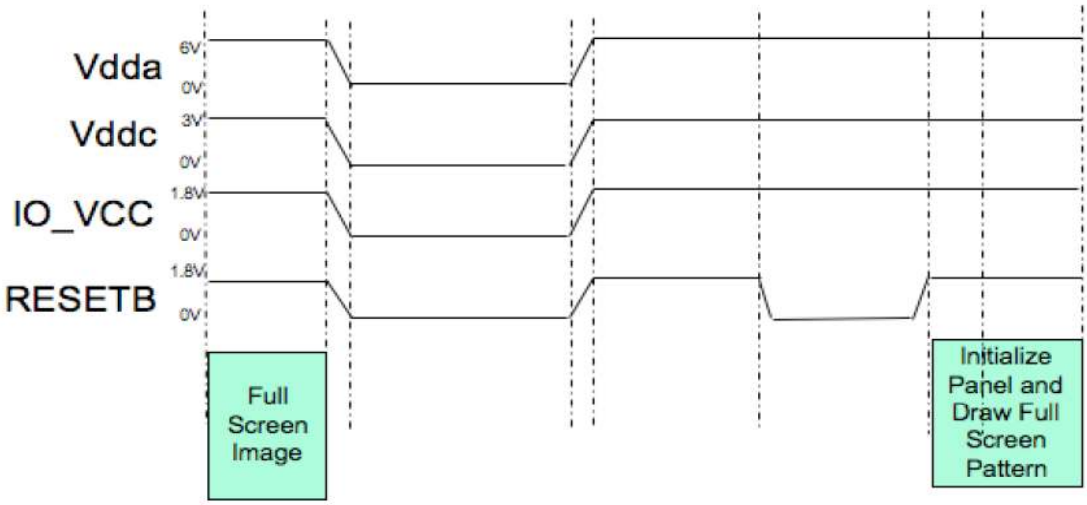


그림4-5. Hard Reset Sequence

4.7 Software Flow & Register Setting

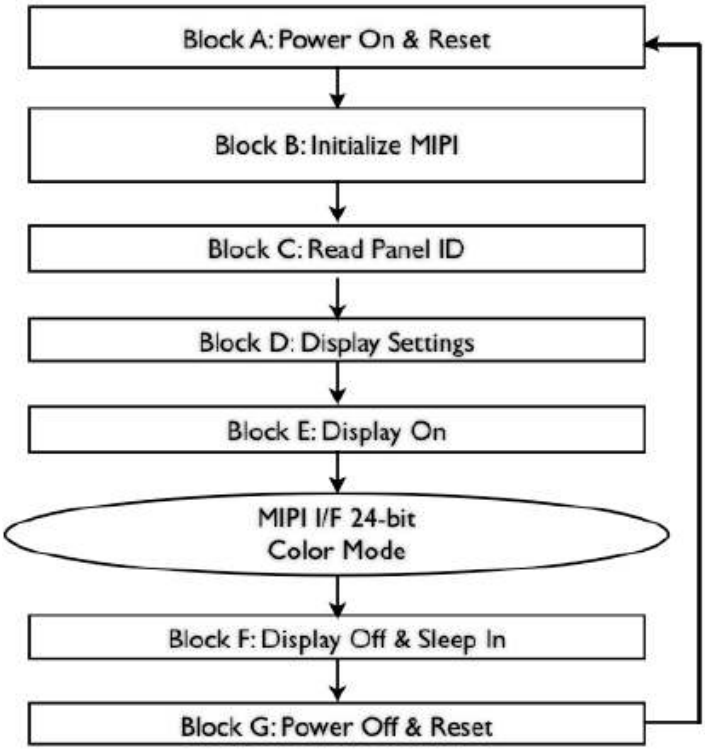


그림4-6. Software Flowchart

Table 4-5-1. Block A : Power off & Reset

Step	Operation
1	Apply IO_VCC
2	Apply VDDC/VDDA
3	Toggle Reset

Table 4-5-2. Block B : Initialize MIPI

Step	Register/ Command	Parameter/ Setting	Operation
1			Initialize SOC DSIM
2	0x00		Send MIPI NOP
3			Start MIPI Highspeed Clock

Table 4-5-3. Block C : Read Panel ID

Step	Register/ Command	Parameter/ Setting	Operation
1	0xB1	0x14	Read ID

Table 4-5-4. Block D : Display Setting

Step	Register/ Command	Parameter/ Setting	Operation
1	Optionally override EEPROM settings in supplier specific electrical specification		

Table 4-5-5. Block E : Sleep Out & Display On

Step	Register/ Command	Parameter/ Setting	Operation
1	0x11		Sleep Out
2	0x29		Display On

Table 4-5-6. Block F : Display Off & Sleep In

Step	Register/ Command	Parameter/ Setting	Operation
1			Draw White
2	0x28		Display Off
3	0x10		Sleep In

Table 4-5-7. Block G : Power Off & Reset

Step	Register/ Command	Parameter/ Setting	Operation
1	Power down simultaneously or IO_VCC logic first then VDDC supply.		

5. 전기광학 특성

5.1 광학특성

Backlight Off

Table 5-1. Optical Characteristics – Backlight Off

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Remarks
Viewing angle range	θ_{LEFT}	CR ≥ 2	45	-	-	° (degree)	Note 1,2,3
	θ_{UP}		45	-	-	° (degree)	Note 1,2,3
	θ_{RIGHT}		45	-	-	° (degree)	Note 1,2,3
	θ_{DOWN}		45	-	-	° (degree)	Note 1,2,3
Contrast ratio	CR	Optimal	6	-	-	--	Note 1,2,**6**
Reflectivity	R	Optimal	1.15	1.8	-	%	Note 1,4,**6**
Border Reflectivity	R	Optimal	1.15	1.8	-	%	Note 1,4,7
Response rise time	τ r	θ = 0°	-	10	15	ms	Note 1,5
Response fall time	τ d	Ta=25°C	-	20	30	ms	Note 1,5
White Chromaticity	X	CIE	0.289	0.309	0.329	--	Note 1,**6**
	Y		0.313	0.333	0.353	--	Note 1,**6**
Red Chromaticity	X	CIE	0.409	0.424	0.459	--	Note 1,**6**
	Y		0.288	0.313	0.338	--	Note 1,**6**
Green Chromatic-ity	X	CIE	0.270	0.295	0.320	--	Note 1,**6**
	Y		0.370	0.395	0.420	--	Note 1,**6**
Blue Chromaticity	X	CIE	0.189	0.219	0.239	--	Note 1,**6**
	Y		0.188	0.218	0.238	--	Note 1,**6**

Note 1: The testing conditions are illustrated in Figure 4-1 and taken at Ta = 25°C in a dark room with a D65 light source. The display is oriented portrait with the driver on the top.
Note 2: The definition of contrast ratio is shown in Section 4.2.1.
Note 3: The definition of viewing angle is shown in Section 4.2.2.
Note 4: The definition of reflectivity is shown in Section 4.2.3 and based on the DMS diffuse measurement system.
Note 5: The definition of response time is shown in Section 4.2.4.
Note 6: **Critical optical characteristics.**
Note 7: The border viewing area must look the same as the active area with the backlight off.

Backlight On

Table 5-2. Optical Characteristics – Backlight On

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Notes
Contrast Viewing Angle Range	θ_{LEFT}	CR ≥ 10	50	60		Degrees	1,2,3
	θ_{UP}		50	60		Degrees	1,2,3
	θ_{RIGHT}		50	60		Degrees	1,2,3
	θ_{DOWN}		47	57		Degrees	1,2,3
	$\theta_{1:30}$		50	60		Degrees	1,2,3
	$\theta_{4:30}$		50	60		Degrees	1,2,3
	$\theta_{7:30}$		45	55		Degrees	1,2,3
	$\theta_{10:30}$		50	60		Degrees	1,2,3
No High Gray Level (white) Inversion Angle	θ_{LEFT}	High Gray Level = lighter shades	50	60		Degrees	1,2,3
	θ_{UP}		50	60		Degrees	1,2,3
	θ_{RIGHT}		50	60		Degrees	1,2,3
	θ_{DOWN}		50	60		Degrees	1,2,3
	$\theta_{1:30}$		50	60		Degrees	1,2,3
	$\theta_{4:30}$		40	60		Degrees	1,2,3
	$\theta_{7:30}$		25	35		Degrees	1,2,3
	$\theta_{10:30}$		50	60		Degrees	1,2,3
No Low Gray Level (black) Inversion Angle	θ_{LEFT}	Low Gray Level = darker shades	50	60		Degrees	1,2,3
	θ_{UP}		47	60		Degrees	1,2,3
	θ_{RIGHT}		50	60		Degrees	1,2,3
	θ_{DOWN}		50	60		Degrees	1,2,3
	$\theta_{1:30}$		17	40		Degrees	1,2,3
	$\theta_{4:30}$		40	60		Degrees	1,2,3
	$\theta_{7:30}$		50	60		Degrees	1,2,3
	$\theta_{10:30}$		50	60		Degrees	1,2,3
Contrast ratio	CR	Optimal	150	200		--	1,2,**6**
Brightness	Y	Optimal	400	450		cd/m^2	1,**6**,12
Brightness Uniformity	Y	Optimal	85			%	1,5,12
Gamma	γ	Optimal		Apple			7
Blue Shift	Δx	Optimal			-0.03		1,14
	Δy	Optimal			-0.05		1,14
Flicker	F	Optimal			**2[illegible]**	**- [illegible]dB**	8
Cross Talk	D_{SHA}	Optimal			4	%	9
Viewing Direction				7:30		o'clock	10
Response rise time	τ r	θ = 0° Ta=25°C		6	15	ms	1,5
Response fall time	τ d			20	30	ms	1,5
Max Gray to Gray	τ r or τ d			40	50	ms	1,5,13
White Chromaticity	x	CIE		0.309		--	1,**6**,11
	y			0.324		--	1,**6**,11

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Notes
Red Chromaticity	x	CIE		0.605		--	1,6,11
	y			0.350		--	1,6,11
Green Chromaticity	x	CIE		0.330		--	1,6,11
	Y			0.555		--	1,6,11
Blue Chromaticity	X	CIE		0.150		--	1,6,11
	Y			0.120		--	1,6,11

Note 1: The testing conditions are illustrated in Figure 4-2 and taken at Ta = 25°C in a dark room using ELDIM EZ Color system and Photo Research PR-650 Colorimeter. The display is oriented portrait with the driver on the top.
Note 2: The definition of contrast ratio is shown in Section 4.2.1.
Note 3: The definition of viewing angle is shown in Section 4.2.2.
Note 4: The definition of response time is shown in Section 4.2.4.
Note 5: The definition of brightness & brightness uniformity is shown in Section 4.2.5.
Note 6: **Critical optical characteristics.**
Note 7: The gray scale linearity or gamma performance is specified in Section 4.3.
Note 8: The flicker level is specified in Section 4.4. Equipment correlation for the maximum level may be needed case-by-case.
Note 9: The cross talk is specified in Section 4.5.
Note 10: The viewing/rubbing direction is the direction of least color inversion.
Note 11: The color coordinate tolerance is plotted in Section 4.6. The white spec is specific for each supplier.
Note 12: Brightness may also be referred to as luminance.
Note 13: The maximum gray to gray response time is based on 9 levels.
Note 14: The maximum blue shift is for all 9 levels.

※ 광학 측정 장비 및 방법은 5.3를 참조한다

5.3 측정장치 및 측정조건

5.3.1 측정 장치

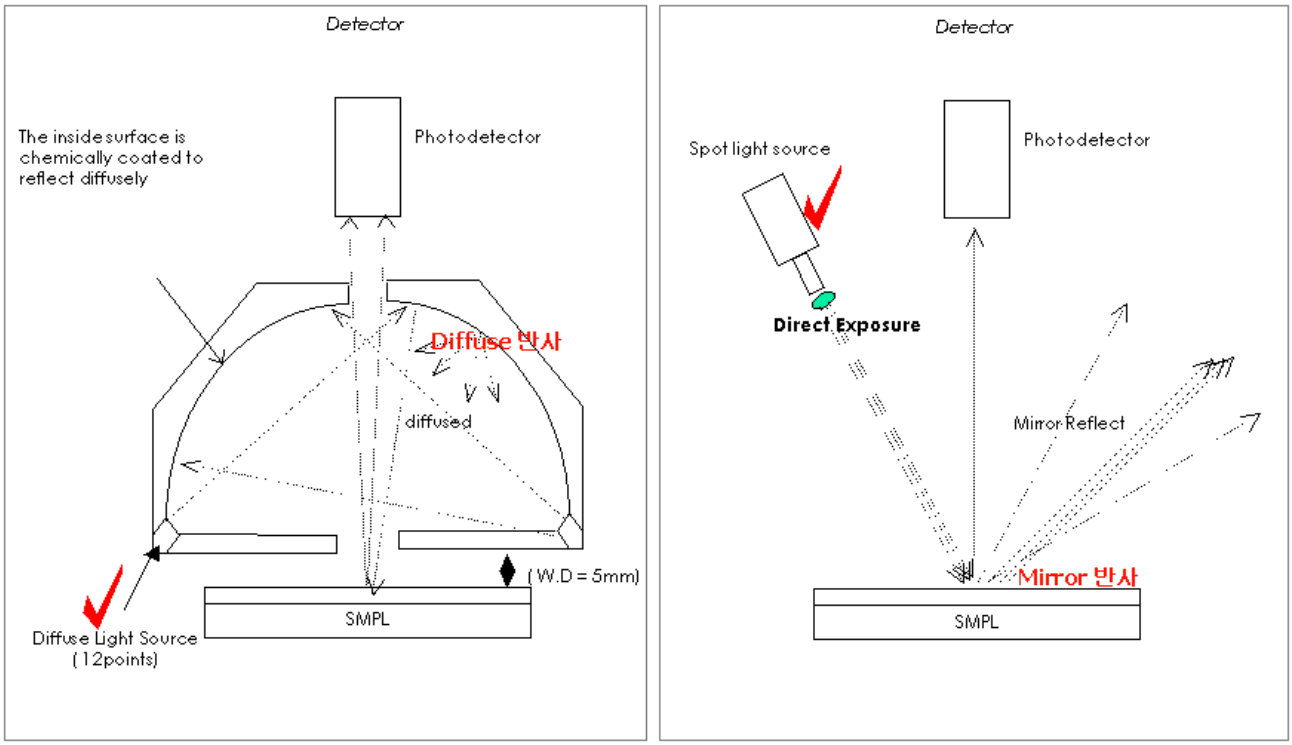


그림 5--1. Backlight Off(DMS-803)

Viewing Angle Measurement

Brightness & Color Measurement

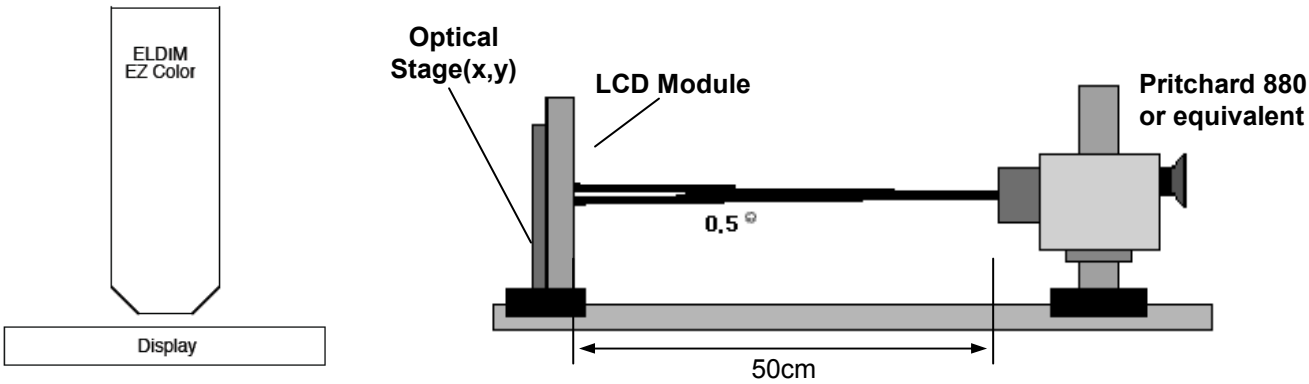


그림 5-2. Backlight On

5.3.2 측정 조건

5.3.2.1 주변 온도 25℃ ± 2℃ 및 조도 8Lux 이하에서 측정한다.

5.3.2.2 LED전류는 20mA 임.

5.3.2.3 30분 이상을 유지 후 실시한다.

5.3.2.4 입력 전압 및 신호조건은 제품 규격의 표준 조건에서 실시한다

5.3.3 Contrast Ratio (CR)

$$\text{Contrast Ratio(CR)} = \frac{\text{Photo detector output with all pixels white}}{\text{Photo detector output with all pixels black}}$$

5.3.4 시야각 정의

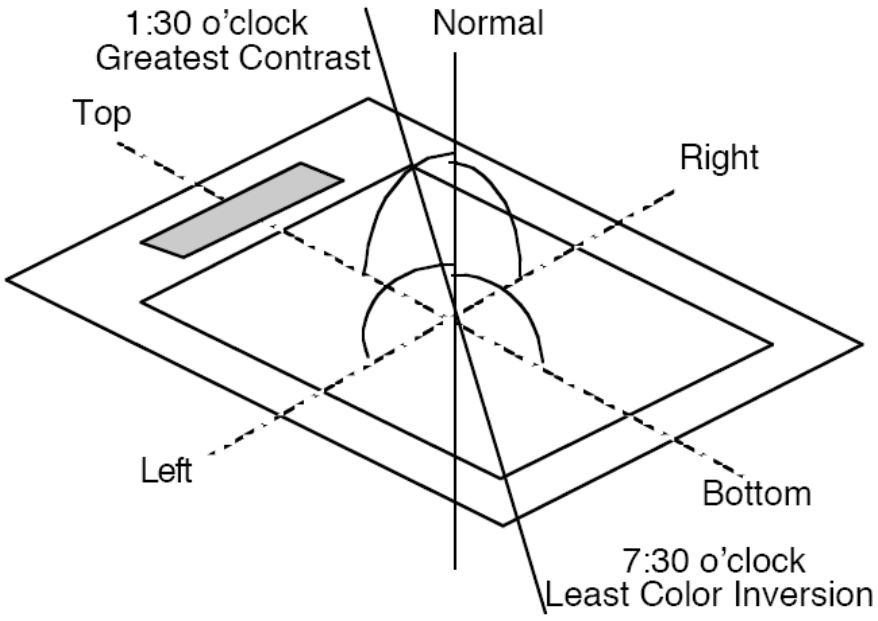


그림 5-3. 시야각의 정의

5.3.5 응답시간의 정의.

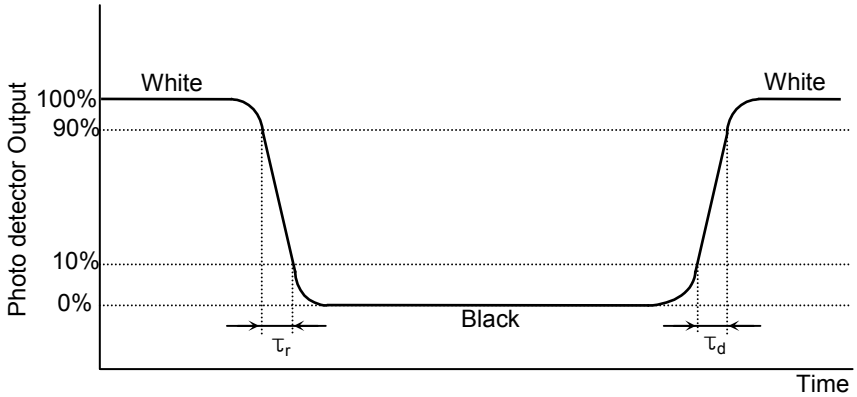


그림 5- 4. 응답시간의 정의

5.3.6 휘도 및 휘도 균일도

휘도는 B7위치 Center 1Point를 측정함

$$\text{휘도 균일도 (\%)} = \left(\frac{\text{Minimum Photo detector output for B1-B13 with all pixels white}}{\text{Maximum Photo detector output for B1-B13 with all pixels white}} \right) \times 100$$

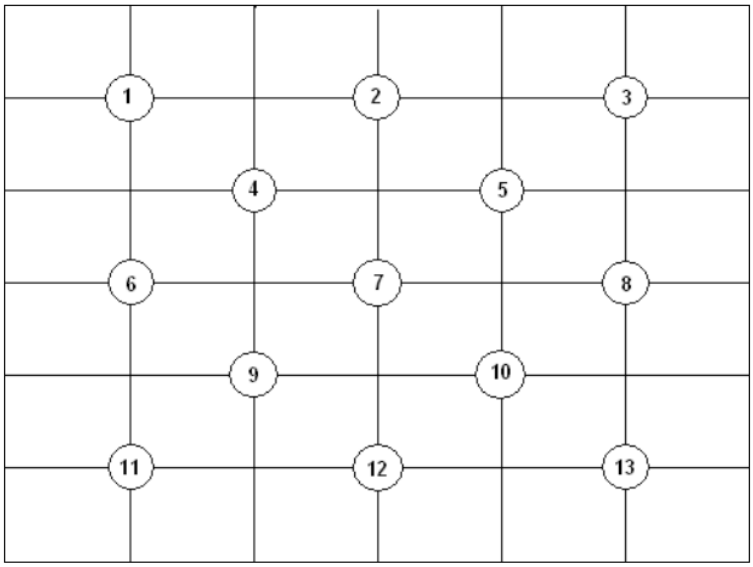


그림 5-5. 휘도 균일도의 정의

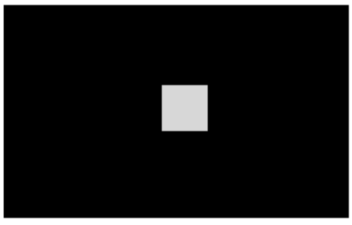
5.3.7 Crosstalk의 정의

Two luminace valuse are measured at the center spot with 50 x 50 pixels. The cross-talk, D_{SHA}, is defined as :

$$D_{SHA} = \left(\frac{(L_B - L_A)}{L_B} \right) x100\%$$

Where, L_A = Luminance in Pattern A
L_B = Luminance in Pattern B.

Pattern A



Pattern A
Gray Scale = 127 in center
Black in surrounding area

Pattern B

Pattern A
Gray Scale = 127 full screen

그림 5-6. Crosstalk의 정의

5.3.8 Flicker 의 정의

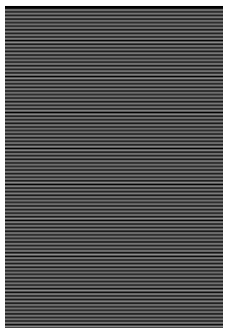


그림 5-7. Black & Middle Gray Horizontal line pattern

Flicker는 30 Hz (P_X) and 0 Hz (P_0) 주파수 스펙트럼내 파워의 비이다.

$$F = 100 \times (P_X / P_0)$$

5.3.9 Gray Scale 규격

Table 5-3. Gray Scale

Gray Level (out of 64)	Apple Target 200:1 CR	Gray Level (out of 64)	Apple Target 200:1 CR	Gray Level (out of 64)	Apple Target 200:1 CR
63	100	42	40.5149	21	9.56635
62	96.4461	41	38.43675	20	8.7052
61	92.96735	40	36.4229	19	7.89395
60	89.56335	39	34.4729	18	7.1317
59	86.2336	38	32.5862	17	6.4176
58	82.97765	37	30.7621	16	5.7507
57	79.795	36	29	15	5.13005
56	76.6852	35	27.2993	14	4.55475
55	73.64775	34	25.6594	13	4.0238
54	70.68215	33	24.0797	12	3.53605
53	67.7879	32	22.5594	11	3.0906
52	64.96455	31	21.09795	10	2.6862
51	62.2116	30	19.6947	9	2.32175
50	59.52845	29	18.349	8	1.99605
49	56.91465	28	17.06	7	1.70775
48	54.36965	27	15.8271	6	1.4556
47	51.893	26	14.6496	5	1.2381
46	49.484	25	13.5267	4	1.05375
45	47.1423	24	12.4577	3	0.90095
44	44.86725	23	11.44185	2	0.7747
43	42.65835	22	10.4783	1	0.65255
				0	0.53035

5.3.10 투과모드white & color 좌표

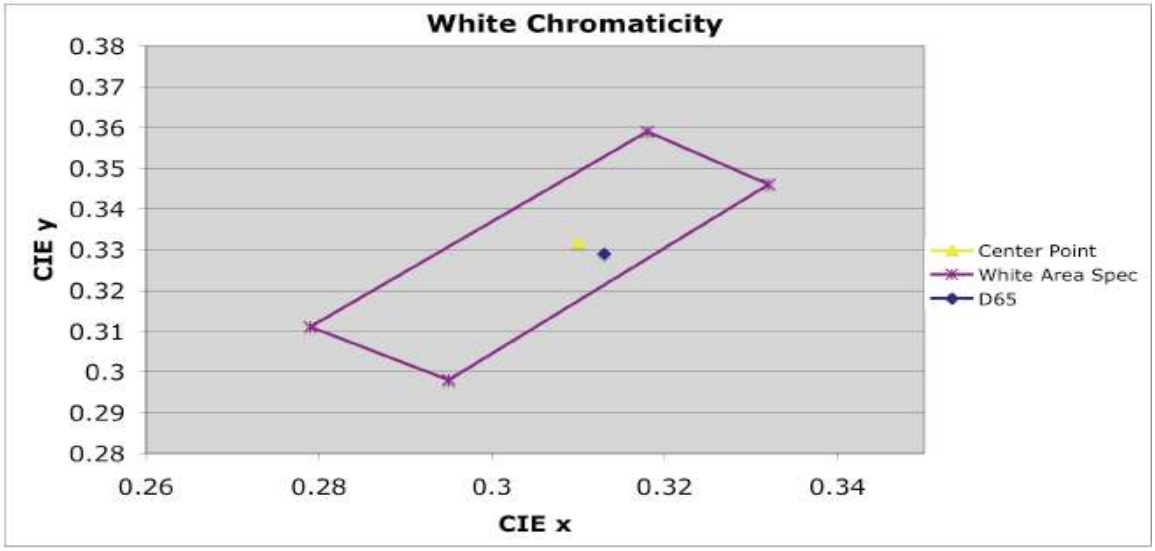


그림 5-8. Transmissive White Chromaticity Area

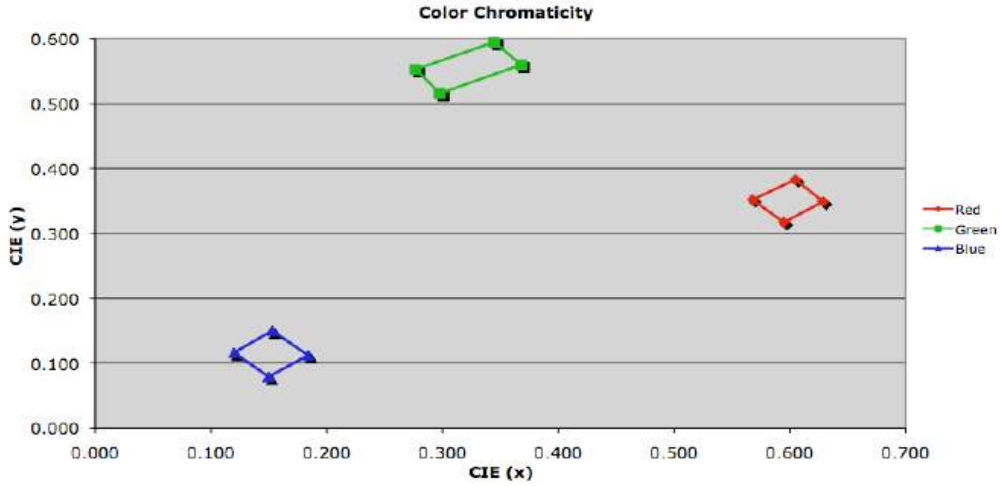


그림 5-9. Transmissive Color Chromaticity Area

Table 5-4. Transmissive Chromaticity White & Color Center Point

White x	White y
0.309	0.324

Red x	Red y	Green x	Green y	Blue x	Blue y
0.605	.350	.330	.555	.150	.120

Table 5.5. Transmissive Chromaticity White & Color Data Boundaries

White x	White y
0.295	0.298
0.279	0.311
0.318	0.359
0.332	0.346

Red x	Red y	Green x	Green y	Blue x	Blue y
0.595	0.317	0.298	0.516	0.150	0.079
0.568	0.352	0.277	0.553	0.120	0.116
0.605	0.383	0.345	0.595	0.153	0.150
0.629	0.349	0.368	0.560	0.184	0.112

5.3.11 Image Sticking

After displaying the checker pattern for 60 hours at room temperature (about 25°C), the persisting image of the pattern shall disappear within 60 seconds on a middle-gray background.

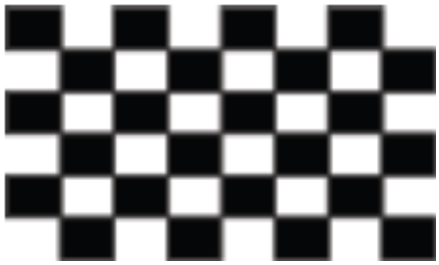


그림 5-10. Checker pattern(20 pixels per box)

6. 기계적 규격

6.1 기계적 규격

Table 6-1. Mechanical Characteristics

항목	규 격	단위	공 차
외곽치수	55.14(H) x 82.84(V) x 1.65 (T)	㎜	H, V: ±0.1, T: +0.10, -0.10
유효 표시 영역	49.92(H) x 74.88(V)	㎜	H : ±0.08, V : ±0.1
무게	15 (Typ.)	g	-

- 상세 치수는 외곽 치수 도면을 참고 할 것.

6.2 제품 라벨 규격

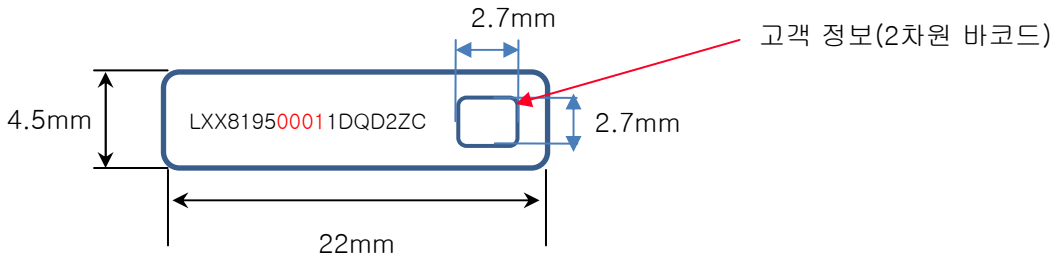


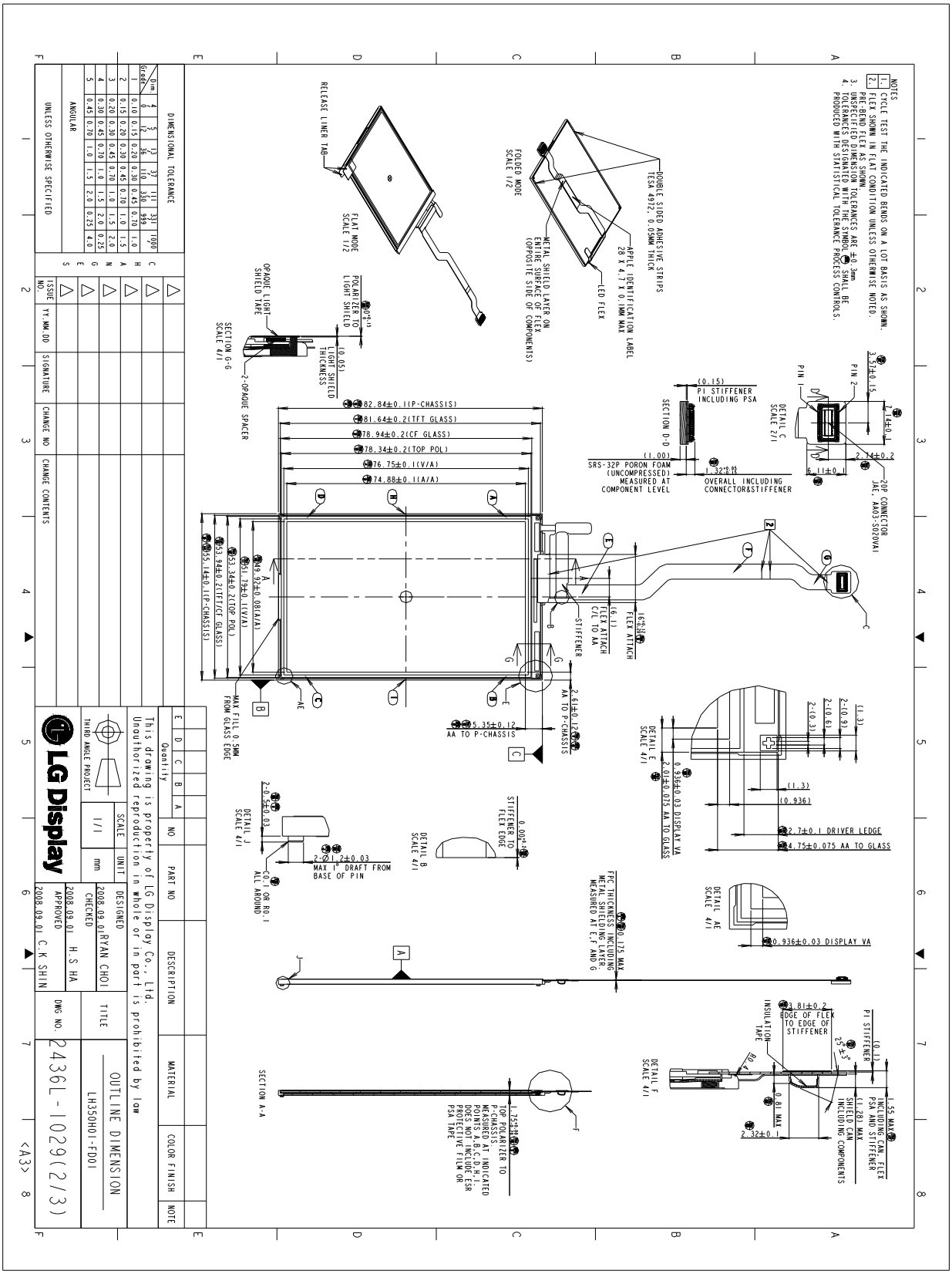
그림 6-1. Label 규격

Table 6-2. Label Characteristics

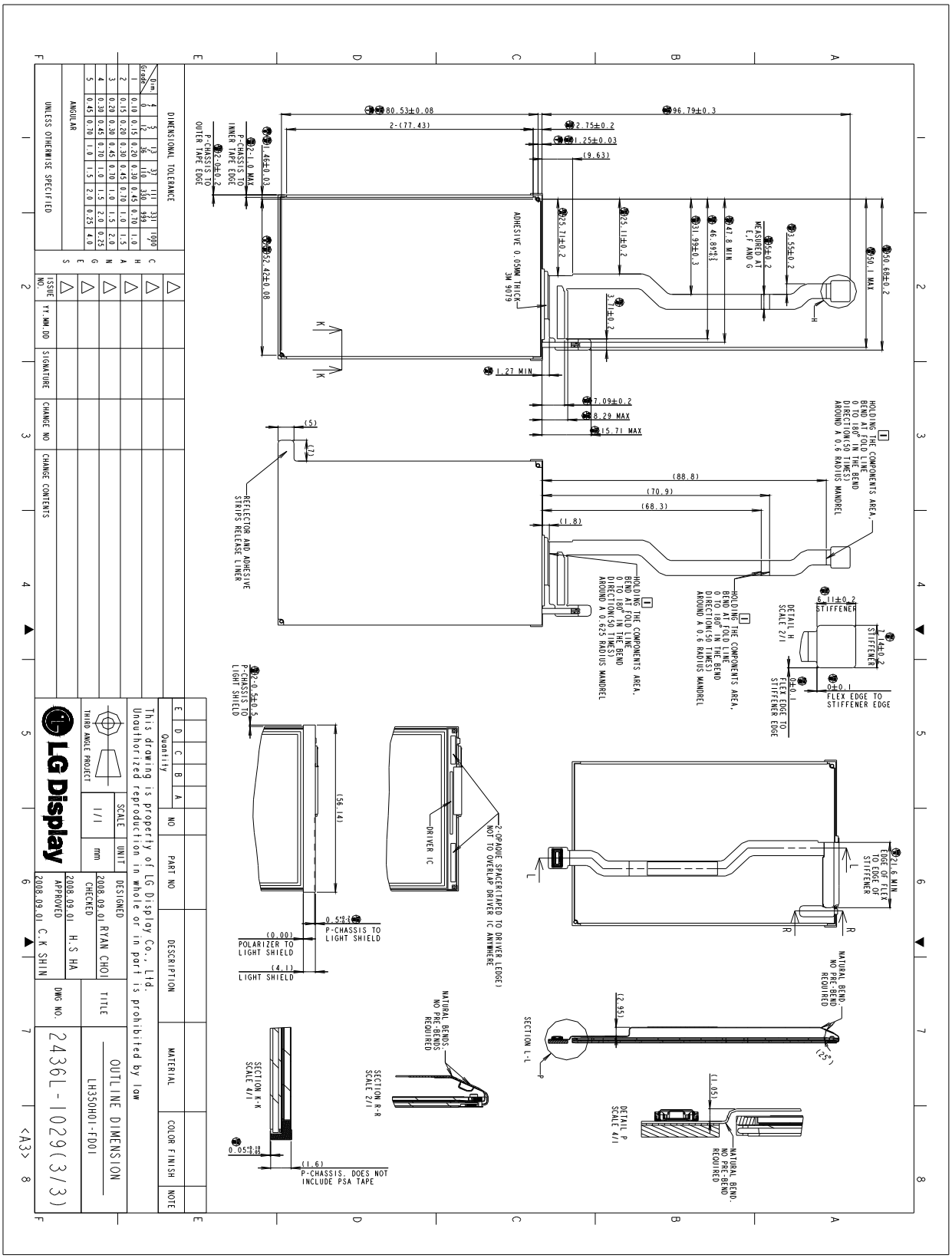
L	LGD	XX	생산공장
8195	08년 19번째 주 5번째 일	0001	매일 순차 발생
1DQ	Apple 사 승인	D2	DVT2
Z	Without Data (단 D는 With Data)	C	고객 승인

6.3 외곽 치수 도면

Outline Dimension 1/2



Outline Dimension 2/2



7. 신뢰성 조건

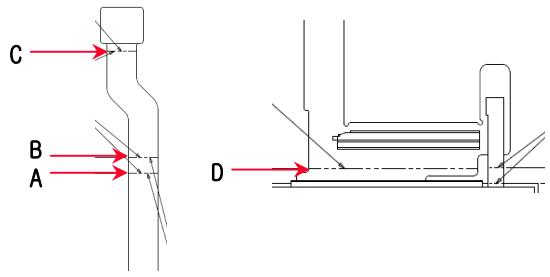
Table 7-1. Environmental & Reliability Requirements

No.	Test Items	Test Condition	Remark
1	저온 보존	Ta=-30℃ 500hrs	
2	고온 보존	Ta=80℃ 500hrs	
3	저온 동작	Ta=-20℃ 500hrs	
4	고온 동작	Ta=70℃ 500hrs	
5	고온 고습 동작	Ta=50℃ 90%RH 240hrs	
6	고온 고습 보존	Ta=65℃ 90%RH 500hrs	
7	ESD(Electro Static Discharge)	2kV once to each terminal.	Non-operating
8	Low Pressure Non-operating	303hpa(40,000ft), RT, 48hrs	
9	Corner T&H 동작	24hrs: 40°C 95% RH 24hrs: 60°C 5% RH 24hrs: -15°C uncontrolled RH	
10	열충격	-30 to +80C, 100 cycles, 3min transfer, 15min dwell	
11	Flex bending test	0 ° <-> 180° around 0.6 radius mandrel(50 times)	Note 1
12	Glass Strength test(4PB)	Weibull 90%기준(Module Level) - Orientation A: 40N 이상 - Orientation C: 100N 이상	Note 2

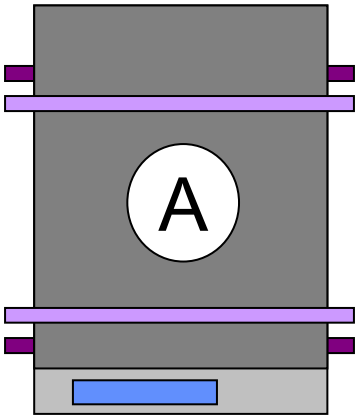
▶ Ta = 주위 온도(Ambient Temperature)

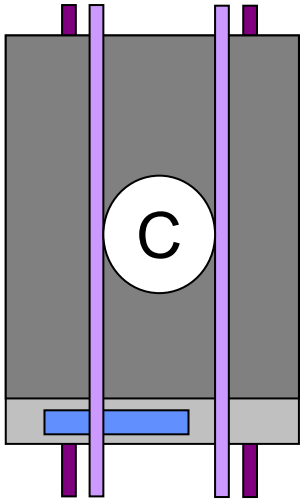
▶ Result Evaluation Criteria
TFT-LCD Panel should be at room temperature for 2 hours after the Reliability test is over.
There should be no particular change which might affect the practical display function
and the display quality should be conducted under normal operating condition.

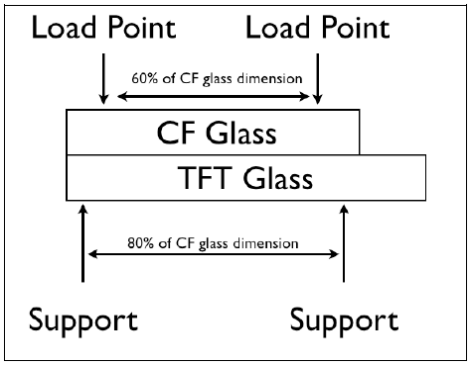
Note 1
1) Room Temp.(25℃) : A, B, C, D 지점
2) Heat soak high Temp. & high Humidity : A, B, C, D 지점
(3hrs ramp to 65°C 90% RH, 72hrs soak → 4hrs ramp to ambient)
3) Thermal cycling : A, B, C, D 지점
(6 cycles, 4hrs ramp to 65°C 90% RH, 2hrs soak → 4hrs ramp to -20°C uncontrolled RH, 2hrs soak)
※ 최소 15회 이상 기능유지

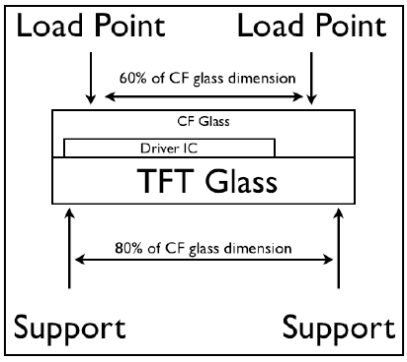


Note 2
1) 4 Point Bend Test : Orientation A, C
2) Glass & Module









8. 품질 검사 규격

신뢰성 시험 및 판정은 고객社(Apple) Display Spec.(069-2631)에 준하며
기타 사항은 LPL 표준 규격으로 실시한다.

8.1 화질 검사 환경

온도: 25 ±5[℃], 습도: 65 ±5[%RH], 조명: 조도 500 Lux,
시야각 범위 내에서 관찰한다.

8.2 시험 규격

제품 인정 시험 규격에 준한다.

8.3 제품 외관 검사 규격

외관 검사 규격에 준한다.

9. 취급상 유의 사항

TFT-LCD Module을 사용할 때 다음 사항에 주의하여야 한다.

9.1 장착 시 주의사항

9.1.1 Module 탈 부착은 System의 전원이 Off된 상태에서 한다.

9.1.2 Module은 외부에서 Case 위에 인가되는 직접적인 압력에 강하지 못하므로 장착 시 뒤틀림과 같은 불 균일한 힘이 인가되지 않도록 한다.

9.1.3 Polarizer 표면을 보호하기 위해 외부의 힘에 충분히 강한 투명한 보호 Plate를 부착하여야 한다.

9.1.4 Module의 온도사양을 만족하기 위해서 System의 방열구조 적용하여야 한다.

9.1.5 고온에서의 부식성 Gas에 의한 Polarizer 손상이나, Electro-Chemical 반응에 의한 회로 파손의 원인이 되므로 Acetic산 또는 염소화합물 Type의 재료의 사용은 금한다.

9.1.6 Polarizer 표면을 화학 약품에 오염된 헝겊이나 연필, 핀셋과 같은 날카로운 것으로 누르거나 문지르지 않도록 한다.
또, Polarizer에 유해하므로 기름이 묻은 헝겊이나 노출된 손으로 Polarizer 표면을 만지지 않도록 한다.

9.1.7 Polarizer 표면이 오염되었을 때에는 부드러운 헝겊으로 닦는다.
Polarizer가 손상되므로 Acetone, Toluene, Alcohol과 같은 약품의 사용을 금하며,
Petrolatum Benzene이나 Normal-hexane을 추천한다.

9.1.8 Polarizer 표면에 침이나 물이 떨어진 상태로 장시간 방치 시 Polarizer가 변색되므로 즉시 닦는다.

9.1.9 Module 내부회로는 내구성이 약하므로 Open하지 않도록 한다.

9.1.10 Module를 장착 또는 교체 시에는 반드시 Software Flowchart Spec.을 준하여 Power 및 Signal을 Off후 행한다.

9.2 동작 시 유의 사항

9.2.1 회로의 오동작 원인이 되는 spike noise는 $V_{AA\text{-}spike}$ =±200mV이하로 관리할 것.

9.2.2 응답 시간과 휘도는 온도에 의존하고, 온도가 낮을수록 응답 시간은 길어지고 휘도도 낮아진다.

9.2.3 결로는 편광판, 전기적 부품에 손상을 줄 수 있으므로 급격한 온도의 변화가 생기지 않도록 주의할 것.

9.2.4 Module은 장시간 동일pattern이 display되면 잔상이 발생하기 쉬우니 유의할 것.

9.2.5 Module은 고온고습에서 성능 및 수명이 저하되므로 규정된 온도, 습도 내에서 사용할 것.

9.3 정전기 방전 control

Module은 정전기에 강하지 못하므로 취급자는 대전 방지링 등을 이용하여 Ground를 하고, 직접적인 Interface 와의 접촉을 금한다.

9.4 강한 빛에의 노출

강한 빛에의 노출은 편광판 및 color filter의 노화의 원인으로 작용하니 유의할 것.

9.5 보관상의 유의사항 (장시간 Module을 보관할 경우에는 다음 사항에 유의할 것)

9.5.1 Module은 직사광선 등의 불빛을 피한 어두운 곳에 보관하며, 상온 상습(5 ~ 35도) 사이에서 보관할 것.

9.5.2 편광판 표면에 다른 물체가 닿지 않도록 하며, 가능하면 지정된 용기에 보관할 것.

9.5.3 Acetic산 또는 염소화합물은 module을 손상 시킬 수 있으므로 피할 것.

9.6 보호 필름의 취급상 유의점

보호 필름을 제거할 때에는 편광판과 보호 필름의 사이에서 정전기가 발생할 수 있으므로 ion blow 또는 동등의 장비를 사용하고, 접지가 잘된 장소에서 천천히 주의해서 제거한다.

9.7 안전성

Module이 깨어질 경우 상해의 위험이 있으므로 주의할 것.(Glass로 만든 TFT-LCD)