Performance Requirements Specification for the 27-Inch 3D Liquid Crystal Display Module

Contents

Figures

Tables

1 Scope

This drawing details the requirements for a 27.0-Inch diagonal, three-dimensional (3D), active-matrix liquid-crystal display (AMLCD) module with (3840 x RGB x 2160) active area, normally black, addressable thin-film transistor (TFT) pixels utilizing in-plane switching (IPS) technology. The 3D LCD module incorporates a patterned retarder, a light-emitting diode (LED) backlight assembly, and mechanical chassis parts.

- Metric units may apply.

Note: This liquid-crystal display (LCD) contains RoHS-compliant (including lead-free) circuit boards and components.

1.1 Requirement Applicability

The following definitions apply subsequent to this paragraph:

Shall: The word shall denotes an absolute requirement. Any sentence containing the word *shall* represents a firm requirement.

Should: The word should denotes a highly desirable characteristic. Any sentence containing the word *should* represents a design goal.

May: The word may denotes a desirable characteristic. Any sentence containing the word *may* can be implemented at the discretion of the design team. Desirable characteristics, along with highly desirable characteristics, are considered design objectives.

Will: The word *will* denotes a statement of fact. Any sentence containing the word *will* describes a condition external to the device.

2 Applicable Documents

The following documents of the issue in effect on the date of invitations for bids form a part of this drawing to the extent specified herein.

2.1 Commercial and Industry Documents

[1]	AS9102B	Aerospace First Article Inspection Requirement
[2]	JESD22-A114	Electrostatic Discharge (ESD) Sensitivity Testing Human Body Model (HBM)
[3]	JESD625	Requirements for Handling Electrostatic-Discharge-Sensitive (ESDS) Components
[4]	ANSI/ESDA/JEDEC JS-001-2010	For Electrostatic Discharge Sensitivity Testing—Human Body Model (HBM) Component Level
[5]	IDMS	Information Display Measurements Standard (IDMS) Version 1.03, June 1, 2012

3 LCD Component Performance Requirements

This document contains two types of performance requirements. The first type are the requirements and design characteristics that the 3D LCD module absolutely must meet. These are all identified by the inclusion of the word “shall” in the requirement. It is mandatory that the 3D LCD module meet every requirement including the word “shall.” These requirements are all uniquely identified by a subscripted number in parenthesis following the word “shall.” There are also requirements that are imposed upon the user of the 3D LCD module to ensure that the 3D LCD module is operated correctly. These are not requirements that the 3D LCD module is expected to meet. Such requirements are not numbered and do not include the word “shall.” There are additional environmental requirements that the ruggedized 3D LCD module will be expected to survive following appropriate ruggedization and packaging by the user.

3.1 LCD Assembly Configuration

The 3D LCD module **shall**$_{(1)}$ use the LG LM270WR3-SPB1 27.0-Inch LCD as its base, two-dimensional (2D) LCD module. See the LG Display 27.0” UHD TFT LCD specification for more information.

3.2 Mechanical Requirements

3.2.1 LCD Pixel Row to Eyewear Polarization Assignment

The 3D LCD **shall**$_{(2)}$ assign the LCD Pixel Row to the Eyewear Polarization as shown in Figure 3-1.

Note: The right eye channel is assigned to the odd pixel rows and viewed using right circular polarization starting at 1st pixel row.

Note: The left eye channel is assigned to the even pixel rows and viewed using left circular polarization starting at 2nd pixel row.

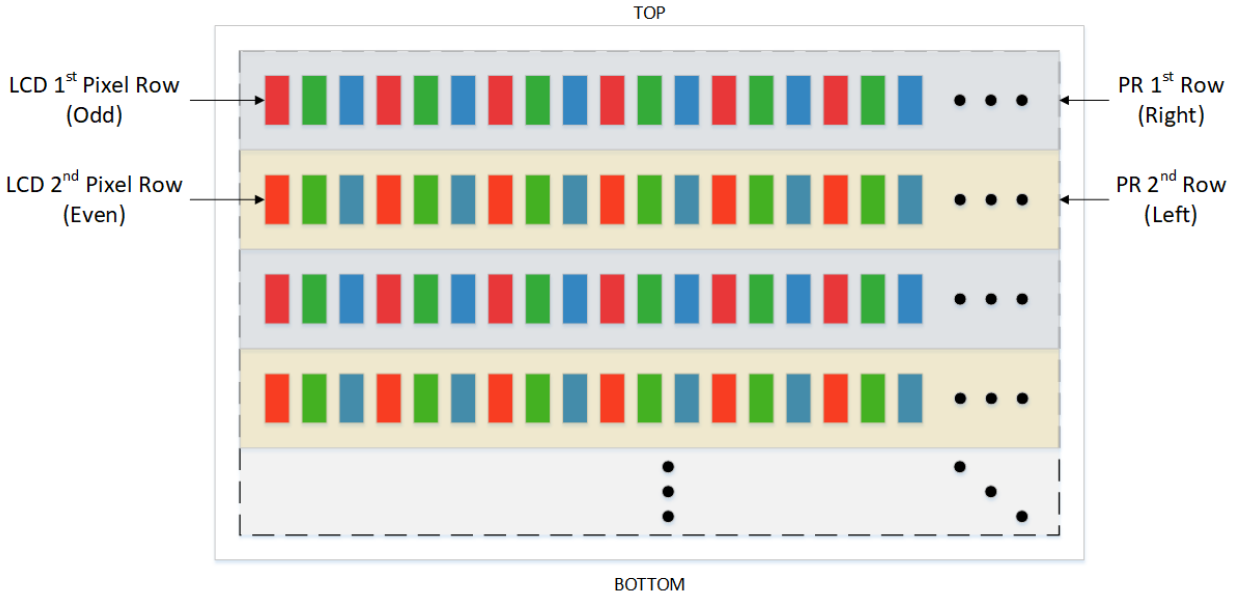


Figure 3-1, LCD Pixel Row / Eyewear Polarization Assignment

Note: The transmission axis of the LG LM270WR3-SPB1 27.0-Inch LCD front polarizer is vertical as shown in Figure 3-2.

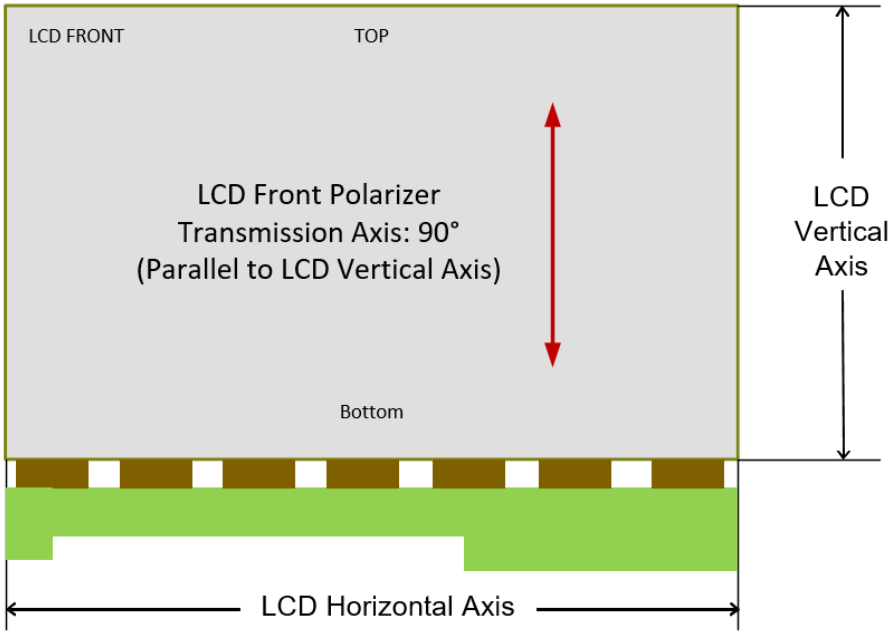


Figure 3-2, LCD Front Polarizer Transmission Axis Orientation

3.2.2 Patterned Retarder Glass Thickness

The nominal glass thickness of the Patterned Retarder, contained within the 3D LCD module, **shall**$_{(3)}$ be 0.5 mm.

3.3 Optical Requirements

3.3.1 3D LCD Design Parameters

The optical requirements of this section requiring measurement are to be met and verified under standard laboratory conditions unless otherwise specified. The standard laboratory conditions are listed in Table 3-1.

Table 3-1, Standard Laboratory Conditions

Parameter	Value
Ambient Temperature	+25°C ±5°C
Relative Humidity	0% to 99% Relative Humidity
Ambient Room Illumination	0 to 100 Lux

3.3.1.1 Stereoscopic Crosstalk

The stereoscopic crosstalk of the 3D LCD **shall**$_{(4)}$ be less than or equal to 4%, in each eye channel, when measured at each of the screen locations defined in section 3.3.1.2 over the range of Upper and Lower Vertical 3D viewing angles specified in section 3.3.1.3.

The stereoscopic crosstalk of the 3D LCD **should** be less than or equal to 2%, in each eye channel, when measured at each of the Central Vertical 3D viewing angles specified in section 3.3.1.3 for Location ID #6, #13, and #16 defined in section 3.3.1.2.

The stereoscopic crosstalk of the 3D LCD **shall**$_{(5)}$ be less than or equal to 4%, in each eye channel, when measured over the range of Horizontal 3D viewing angles specified in section 3.3.1.3 for Location ID #6, #13, and #16 defined in section 3.3.1.2.

3.3.1.1.1 Definition of Stereoscopic Crosstalk

The definition of stereoscopic crosstalk is referenced from Section 17.2.2 in Information Display Measurements Standard Ver. 1.0.3 (June 1, 2012) [5]. The diagram and equations in Figure 3-3 define how stereoscopic crosstalk is determined.

Note: The 3D eyewear properties must be included when reporting the stereoscopic crosstalk measurement results.

Stereo Image Pair	As viewed by Left Eye	As Viewed by Right Eye
WW	W	W
KW	K	W
WK	W	K
KK	K	K

*Description of Image State Designators:

L = Luminance
L or R = As viewed by Left or Right Eye
W or K = White (W) or Black (K) Image on Left Eye and Right Eye Channel, Respectively

Example: L_{LKK}
Luminance of Left Channel Image when Left Image is Black (K) and Right Eye Image is Black (K)

Stereoscopic Crosstalk is calculated as follows:

$$C_L = \frac{(L_{LKW} - L_{LKK})}{(L_{LWK} - L_{LKK})} \text{ x } 100\% = \text{crosstalk of luminance from right eye channel onto left eye channel}$$

$$C_R = \frac{(L_{RWK} - L_{RKK})}{(L_{RKW} - L_{RKK})} \text{ x } 100\% = \text{crosstalk of luminance from left eye channel into right eye channel}$$

Figure 3-3, Stereoscopic Crosstalk Definition

3.3.1.2 Stereoscopic Crosstalk Screen Locations

The stereoscopic crosstalk will be measured at the LCD active area locations shown in Figure 3-4 and specified in Table 3-2 and Table 3-3.

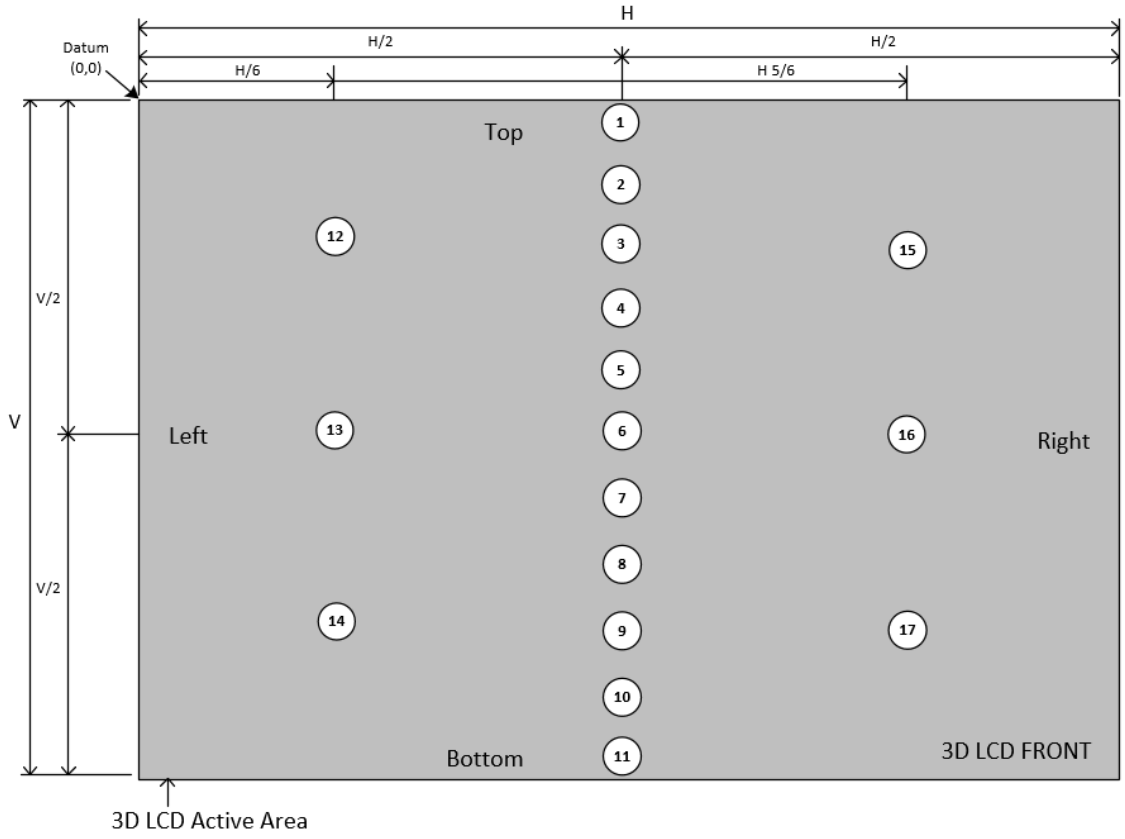


Figure 3-4, 3D LCD Stereoscopic Crosstalk Measurement Locations (Front View)

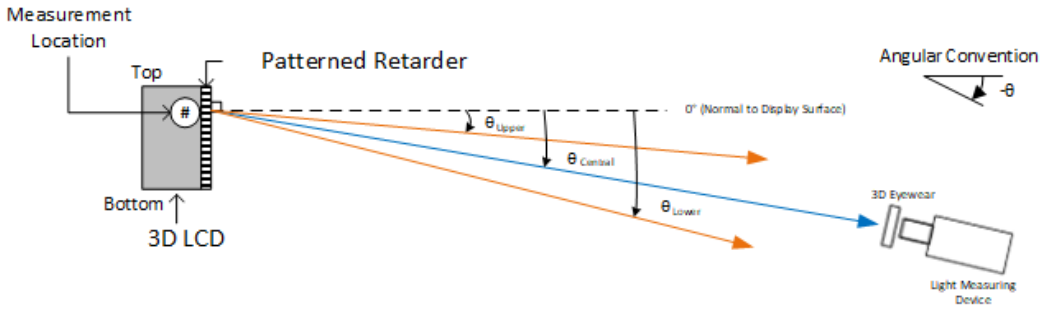
3.3.1.3 Range of 3D Viewing Angles

The 3D LCD stereoscopic crosstalk measurements are to be performed at the corresponding LCD active area locations detailed in section 3.3.1.2 and over the range of 3D viewing angles detailed in Table 3-2 and Table 3-3. The diagram in Figure 3-7 shows the 3D vertical viewing angle measurement setup for the centerline screen locations. The diagram in Figure 3-8 shows the 3D horizontal viewing angle measurement setup for the horizontal screen locations.

Note: A spot size of greater than or equal to 2 mm will be used for crosstalk luminance measurements.

3.3.1.3.1 Definition of 3D Viewing Angles

The stereoscopic crosstalk 3D viewing angle definitions are shown in Figure 3-5 and Figure 3-6.



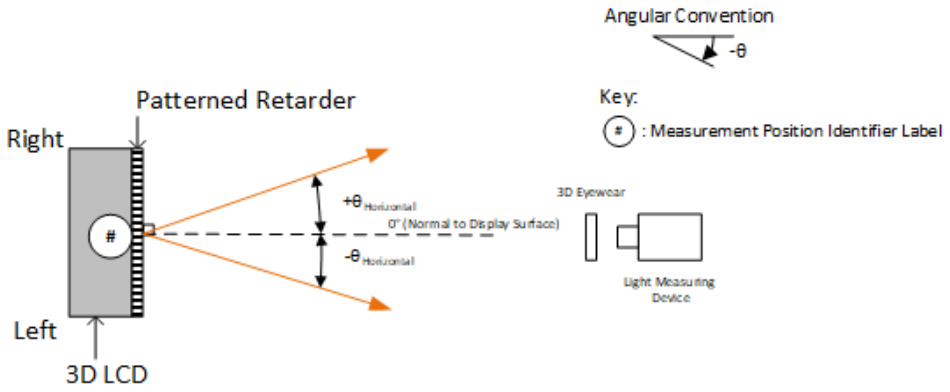
Vertical 3D Viewing Angle Definitions:

$\theta_{Central}$: The primary 3D viewing angle measured from normal to the display surface, represented by the blue arrow

θ_{Upper} : The upper 3D viewing angle for the maximum 3D crosstalk allowed from normal to the display surface, represented by the top orange arrow

θ_{Lower} : The lower 3D viewing angle for the maximum 3D crosstalk allowed from normal to the display surface, represented by the bottom orange arrow

Figure 3-5, Stereoscopic Crosstalk Vertical 3D Viewing Angle Definitions (Side View)



Horizontal 3D Viewing Angle Definitions:

$\theta_{Horizontal}$: The horizontal 3D viewing angle measured from normal to the display surface, represented by the orange arrows

Figure 3-6, Stereoscopic Crosstalk Horizontal 3D Viewing Angle Definition (Top View)

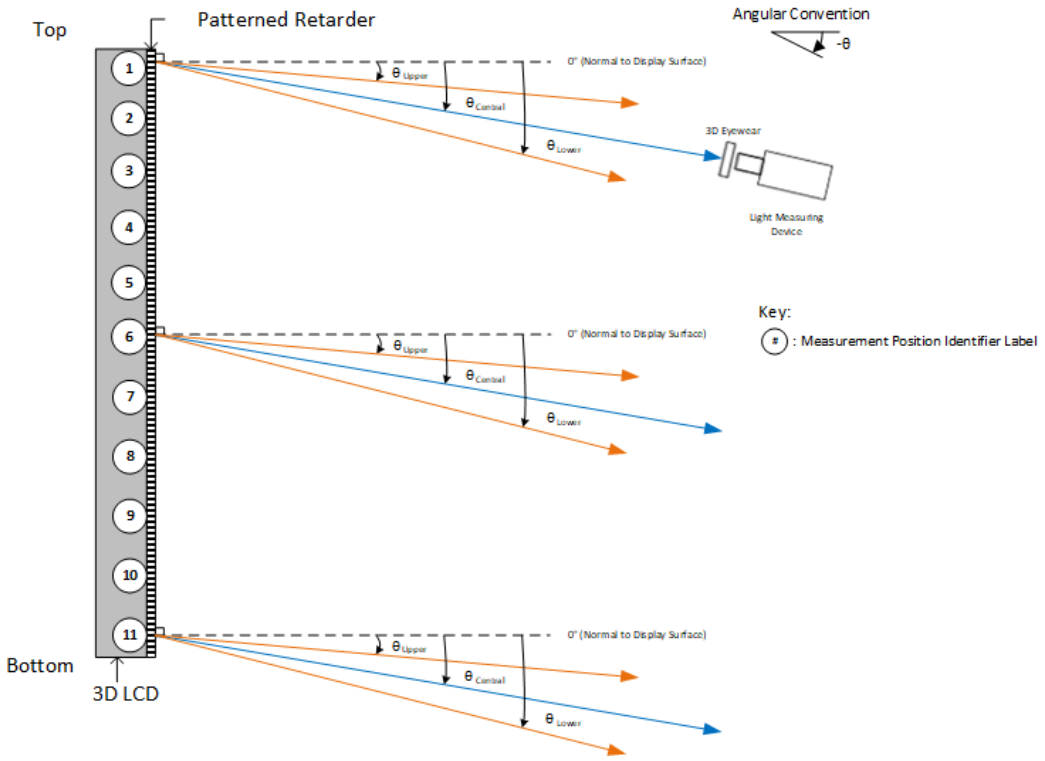


Figure 3-7, Vertical 3D Viewing Angles along Screen Center (Side View)

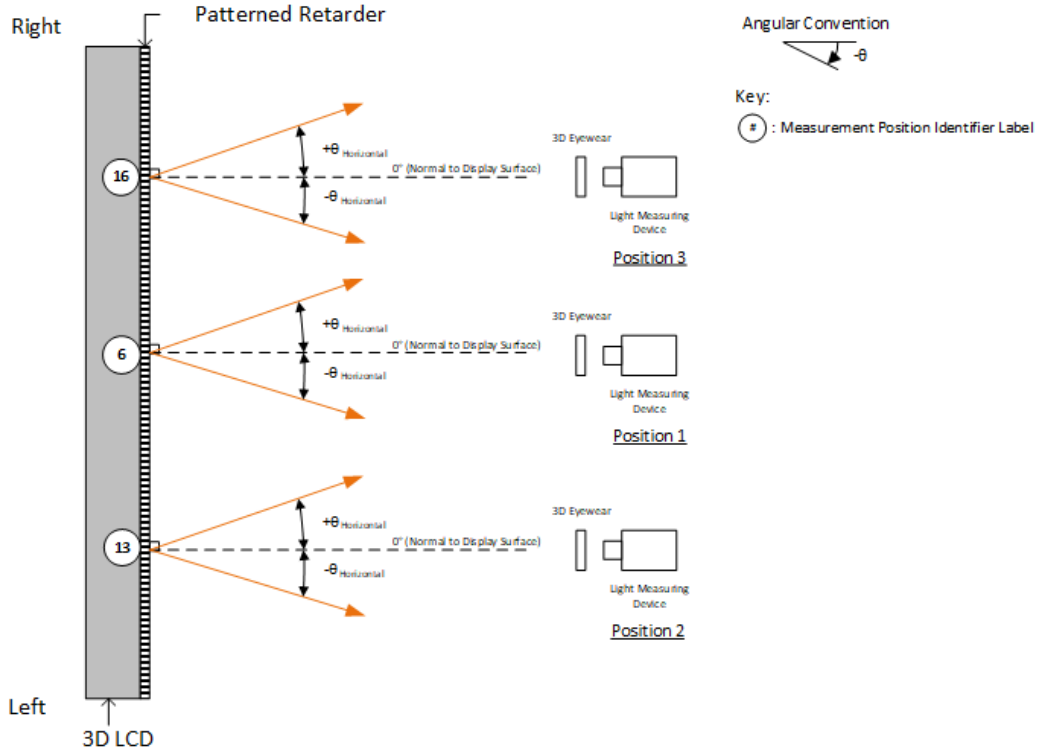


Figure 3-8, Horizontal 3D Viewing Angles (Top View)

Table 3-2, Vertical 3D Viewing Angle Summary

Location ID	Horizontal Screen Location (mm)	Vertical Screen Location (mm)	Horizontal 3D Viewing Angle ($\theta_{Horizontal}$) (Degrees)	Vertical 3D Viewing Central Angle ($\theta_{Central}$) (Degrees)	Vertical 3D Viewing Upper Angle (θ_{Upper}) (Degrees)	Vertical 3D Viewing Lower Angle (θ_{Lower}) (Degrees)	Stereoscopic Crosstalk Limit
1	305.9	27.8	0	-13.8	-10.9	-16.8	≤ 4%
2	305.9	57.8	0	-15.2	-12.3	-18.3	≤ 4%
3	305.9	87.8	0	-16.5	-13.6	-19.6	≤ 4%
4	305.9	117.8	0	-17.7	-14.7	-20.8	≤ 4%
5	305.9	147.8	0	-18.8	-15.7	-21.9	≤ 4%
6	305.9	177.8	0	-19.7	-16.7	-22.8	≤ 4%
7	305.9	207.8	0	-20.5	-17.5	-23.6	≤ 4%
8	305.9	237.8	0	-21.2	-18.3	-24.3	≤ 4%
9	305.9	267.8	0	-21.9	-18.9	-24.9	≤ 4%
10	305.9	297.8	0	-22.4	-19.5	-25.4	≤ 4%
11	305.9	327.8	0	-22.9	-20.0	-25.9	≤ 4%
12	102.0	87.8	0	-16.5	-13.6	-19.6	≤ 4%
13	102.0	177.8	0	-19.7	-16.7	-22.8	≤ 4%
14	102.0	267.8	0	-21.9	-18.9	-24.9	≤ 4%
15	509.8	87.8	0	-16.5	-13.6	-19.6	≤ 4%
16	509.8	177.8	0	-19.7	-16.7	-22.8	≤ 4%
17	509.8	267.8	0	-21.9	-18.9	-24.9	≤ 4%

Table 3-3, Horizontal 3D Viewing Angle Summary

Location ID	Horizontal Screen Location (mm)	Vertical Screen Location (mm)	Positive Horizontal 3D Viewing Angle ($\theta_{Horizontal}$) (Degrees)	Negative Horizontal 3D Viewing Angle ($\theta_{Horizontal}$) (Degrees)	Vertical 3D Viewing Central Angle ($\theta_{Central}$) (Degrees)	Stereoscopic Crosstalk Limit
6	305.9	177.8	+ 20.3	-20.3	-19	≤ 4%
13	102.0	177.8	+20.3	-20.3	-19	≤ 4%
16	509.8	177.8	+20.3	-20.3	-19	≤ 4%

3.3.1.4 Luminance

The luminance of the 3D LCD module **should** be greater than or equal to 70 cd/m^2 when measured without 3D eyewear at Location ID #6 at the 3D Viewing Angle in Table 3-2.

Note: This goal assumes luminance will be measured when the 3D LCD is backlit using the 3D LCD module backlight.

3.3.2 Defects

3.3.2.1 Conditions and Method of Inspection

The conditions and method of inspection of the 3D LCD module are defined by the supplier.

Note: The supplier must provide the conditions and method of inspection once available.

3.3.2.2 Line Defects

The 3D LCD module **shall$_{(6)}$** have no visible line defects on the 3D LCD surface.

3.3.2.3 Standard of Defects

The 3D LCD module **shall$_{(7)}$** meet the inspection defect criteria as defined by the supplier.

Note: The supplier must provide the inspection defect criteria once available.

3.4 Environmental Requirements

3.4.1 Temperature

3.4.1.1 Low Temperature Storage

The 3D LCD **shall$_{(8)}$** show no signs of discoloration or delamination after being stored at –20°C for 240 hours.

The 3D LCD **shall$_{(9)}$** meet the optical requirements defined in section 3.3 after being stored at –20°C for 240 hours.

3.4.1.2 High Temperature Storage

The 3D LCD **shall$_{(10)}$** show no signs of discoloration or delamination after being stored at +60°C for 240 hours.

The 3D LCD **shall$_{(11)}$** meet the optical requirements defined in section 3.3 after being stored at +60°C for 240 hours.

3.4.2 Humidity

The 3D LCD **shall$_{(12)}$** show no signs of discoloration or delamination after being stored in a humid environment of +40°C at 70%RH for 240 hours.

The 3D LCD **shall$_{(13)}$** meet the optical requirements defined in section 3.3 after being stored in a humid environment of +40°C at 70%RH for 240 hours.

4 Preparation for Delivery Requirements

4.1 3D LCD Module Packaging

4.1.1 Container and Protection

Each 3D LCD module **shall**$_{(14)}$ be packaged in a manner that will afford protection against contamination, corrosion, deterioration, and physical damage during shipment and storage. The packaging **shall**$_{(15)}$ allow easy access without damage to the 3D LCD modules. This individual packaging **shall**$_{(16)}$ include a sealed ESD protective bag.

4.1.2 Package Marking

As a minimum, the packaging containing the 3D LCD modules **shall**$_{(17)}$ be marked with the supplier's name or symbol, and the supplier's part number.

4.2 Part Marking

Note: Rockwell Collins will provide a minimum of two labels containing the Rockwell Collins serial number to the supplier.

4.2.1 3D LCD Module Part Marking

As a minimum, the 3D LCD module **shall**$_{(18)}$ be marked with the supplier's name or symbol, supplier's part number, supplier's serial number, and Rockwell Collins serial number.

The 3D LCD module part marking **shall**$_{(19)}$ be located in the approximate location as shown in Figure 4-1.

Figure 4-1, 3D LCD Module Marking Location

4.2.2 LCD Driver Board Part Marking

As a minimum, the LCD driver board, contained within the 3D LCD module, **shall**$_{(20)}$ be marked with the Rockwell Collins serial number.

The LCD driver board part marking **shall**$_{(21)}$ be located in the approximate location as shown in Figure 4-2 and Figure 4-3.

Figure 4-2, LCD Driver Board Marking Location

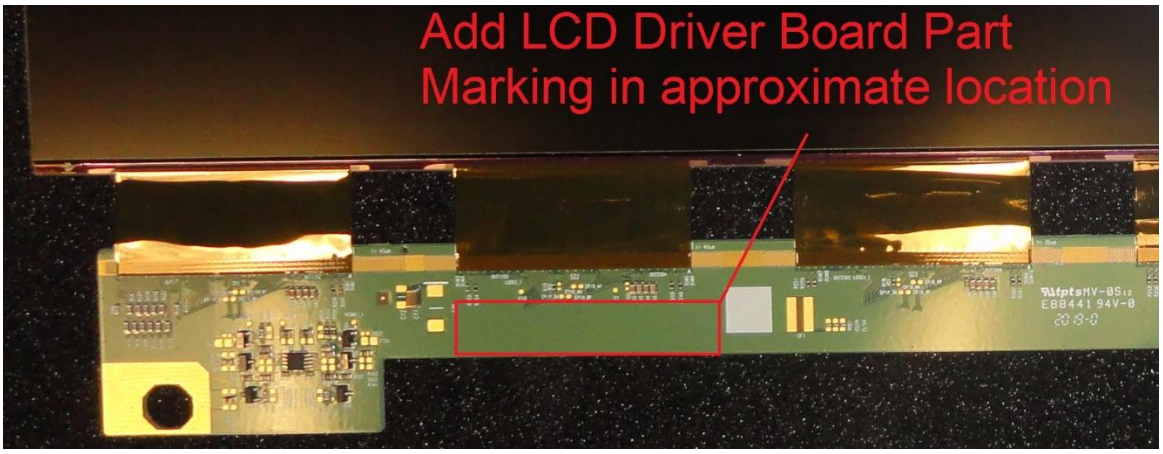


Figure 4-3, LCD Driver Board Marking Location (Zoomed-In View)

4.2.3 ESD Handling

Parts detailed in this specification must be handled in accordance with JESD625 [3] or other industry standard practice and should have an ESDS classification as defined by JESD22-A114 [2] or ANSI/ESDA/JEDEC JS-001-2010 [4] (see example in Table 4-1). Class 0 parts may require special handling over and above what is provided for in JESD625. Class 3B parts are considered non-ESD sensitive and do not require special ESD handling.

Table 4-1, ESD Classification

Class	Voltage Range
0	<250
1A	250 to <500
1B	500 to <1000
1C	1000 to <2000
2	2000 to <4000
3A	4000 to <8000
3B	≥ 8000

The 3D LCD module specified in this document is classified as class 0 and must be handled accordingly. Rockwell Collins recommends a maximum ESD exposure of ±100V.

5 Requirement Verification

To comply with AS9102B [1], the 3D LCD assembly must undergo a First Article Inspection. This action includes a documentation step showing how all requirements of the assembly were verified. The several specific requirements for the assembly, identified with numbered “shalls” in this document, may be verified using several different methodologies. The specific verification methodology can be either a test, an inspection, an analysis, or a supplier certification.

5.1 Verification Methods

5.1.1 Test

In most cases, a requirement is verified by creating and executing a verification test, collecting the results, and determining that the product meets the test requirement. The test procedures and results must be retained for future review.

5.1.2 Inspection

In some cases, a requirement can be verified through inspection. Examples of inspections include labeling, dimensions, and pixel orientation.

5.1.3 Analysis

Some requirements may be verified by analyzing other data or information collected in other ways.

5.1.4 Supplier Certification

Some requirements are impossible to verify on a product. These requirements are verified by a letter from the supplier certifying that those requirements are met.

5.2 Verification Table

The several requirements in this specification will be verified as defined in Table 5-2.

An “X” in the “Method” column of Table 5-2 denotes a required method. An “O” indicates an option that may be performed. The abbreviations in Table 5-1 are used in the Table 5-2 column headings.

Table 5-1, Verification Abbreviations and Definitions

Abbreviation	Definition
T	test
A	analysis
I	inspection
C	supplier certification

Table 5-2, Requirement Verification

Requirements	Paragraph	Requirement Number	Method			
			T	A	I	C
LCD Assembly Configuration	3.1	1			X	
LCD Pixel Row to Eyewear Polarization Assignment	3.2.1	2	X			
Patterned Retarder Glass Thickness	3.2.2	3				X
Stereoscopic Crosstalk	3.3.1.1	4, 5	X			
Line Defects	3.3.2.2	6			X	
Standard of Defects	3.3.2.3	7				X
Low Temperature Storage	3.4.1.1	8			X	
Low Temperature Storage	3.4.1.1	9	X			
High Temperature Storage	3.4.1.2	10			X	
High Temperature Storage	3.4.1.2	11	X			
Humidity	3.4.2	12			X	
Humidity	3.4.2	13	X			
Container and Protection	4.1.1	14, 15, 16			X	
Package Marking	4.1.2	17			X	
3D LCD Module Part Marking	4.2.1	18, 19			X	
LCD Driver Board Part Marking	4.2.2	20, 21			X	

Appendix A Abbreviations and Acronyms

The following abbreviations and acronyms are used in this document:

2D	two-dimensional
3D	three-dimensional
A	analysis
AMLCD	active-matrix liquid-crystal display
ANSI	American National Standards Institute
C	supplier certification
CAGE	Commercial and Government Entity
CFR	Code of Federal Regulations
EAR	Export Administration Regulation
ESD	electrostatic discharge
ESDA	ESD Association
ESDS	electrostatic-discharge-sensitive
HBM	human body model
I	inspection
ID	identification
IDMS	Information Display Measurement Standard
IPS	in-plane switching
JEDEC	Joint Electron Device Engineering Council
LCD	liquid-crystal display
LED	light-emitting diode
PDM	(Rockwell Collins) Product Data Management
RCPN	Rockwell Collins part number
RGB	red, green, blue
RH	relative humidity
RoHS	Restriction of Hazardous Substances
T	test
TFT	thin-film transistor
UHD	ultra high definition
VPN	vendor part number