Hyper-Narrow Bezel (HNB) Video Wall LCD Module with High Picture Quality and Reliability Performance

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Abstract

This paper presents the development of an HNB video wall module with enhanced picture quality and reliability. Utilizing a glass diffusion plate, bezel, tapes, and backlight architecture design, the bezel width is significantly reduced compared to traditional designs. Optimizations in middle frame design resolve dark edge challenges, offering valuable insights for narrow-bezel LCD module design and picture quality enhancement in future applications.

Author Keywords

Hyper narrow bezel (HNB); LCD; video wall module; high reliability; high picture quality

1. Introduction

LCD video wall module products are used for multi-module screen splicing. When the products are spliced, the width of bezel and poor picture quality (such as dark edge) will overlap, resulting in bad visual effect. Therefore, reducing the width of bezel and improving picture quality are the continuous goals pursued by video wall products. But these two key performance of video wall products are limited by traditional design architecture, making it difficult to improve.

As is shown in Figure 1, the traditional design architecture consists of Bezel + Panel + Optical sheets + PS/PC diffusion plate (DP). The main issues include:

1. The large width of the bezel. Due to the high thermal expansion rate of optical sheet materials which mainly made of PET and PS/PC DP, it is necessary to reserve expansion gaps (Red area) at the edges of the module to prevent DP and optical sheets from expanding and wrinkling under high temperature conditions, which may cause the panel skipping. So bezel width can only be 1.2+1.9=3.1mm.

2. Dark edge at the edge of the module (Yellow area). Because the light is reflected by the middle frame and moves away from the edges of the module, light cannot enter the DP support surface area, resulting in dark edge.

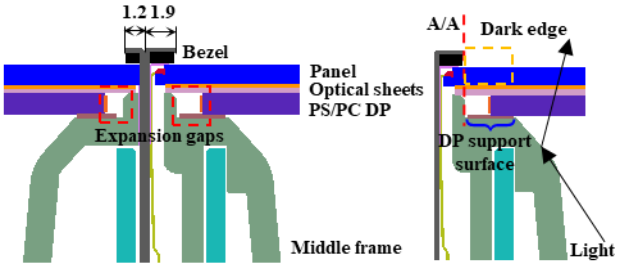

Figure 1. Traditional video wall module design architecture and dark edge

Therefore, a new design architecture of video wall module is needed to solve the two challenges of narrow bezel and high picture quality.

2. Design architecture of HNB video wall module with high reliability

Based on the pain points of traditional video wall module products, a HNB design architecture that can achieve high reliability and narrow bezel is proposed, as shown in the figure 2. The HNB design architecture consists of Glass diffusion plate (Glass DP) + Bezel+ Tapes+ Backlight Unit (BLU) [1].

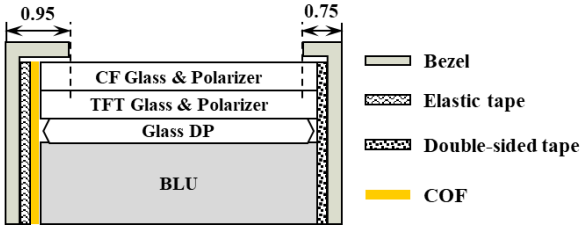

Figure 2. Design architecture of HNB video wall module

2.1 Glass DP design

Glass DP has the advantages of high strength and low thermal expansion rate, and plays a key role in narrowing the bezel and improving the reliability and picture quality of HNB video wall modules.

In the HNB video wall module, a Glass DP is used, and the structure of each layer is shown in the following figure [2].

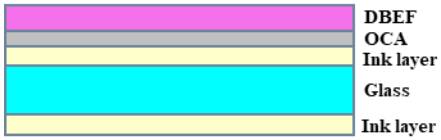

Figure 3. The structure of Glass DP

The Glass DP consists of glass, ink layers on the upper and lower surfaces of the glass, optical clear adhesive (OCA), and DBEF optical sheet. Since the thermal expansion rate of glass is less than one tenth of that of PS and PC, there is no need to reserve large expansion gaps at the edge of the module which can greatly reduce the width of the bezel. After being fully lamination with OCA, DBEF optical sheet will not expand or wrinkle even in high temperature environments under the tension of OCA, so there is also no need to set up expansion space for optical sheet materials. In addition, the Young's modulus of glass is about 35 times that of PS and PC, so it has better capability of anti-deformation and increases the strength and reliability of the module. And the optical performance of glass can also be comparable to traditional PS&PC materials, such as higher visible light transmittance of glass. As the Glass DP does not require supporter which is used in PS/PC DP structure, the assembly efficiency of the module is higher and the assembly cost is lower.

The following table compares the thermal expansion rate, Young's modulus, and visible light transmittance of glass with PS and PC materials.

Table 1. Comparison of material characteristics

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Material	Thermal expansion rate	Young's modulus	Visible light transmittance
PS	$7*10^{-5}$ /℃	2.1-2.3 GPa	89%
PC	$6*10^{-5}$ /℃	2.2-2.4 GPa	90%
Glass	$5*10^{-6}$ /℃	70-90 GPa	91.5%

2.2 Narrow border panel & Bezel design

After Glass DP solves the design limitation of narrow bezel, it is necessary to use panel with narrower borders. As shown in Figure 3, the narrower border panel is used in the HNB video wall module architecture.

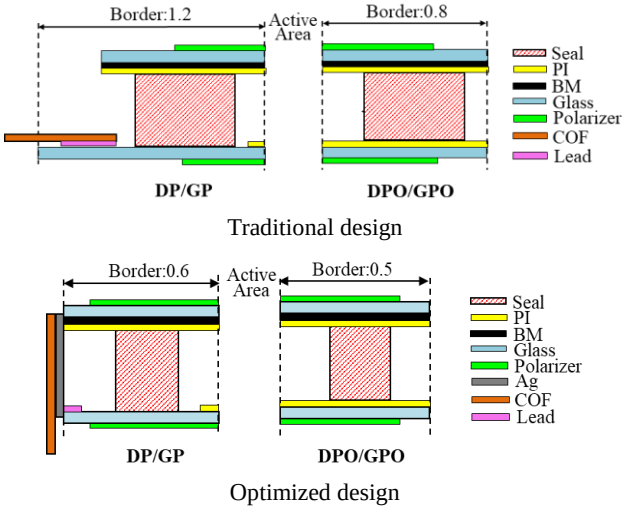


Figure 4. Comparison of narrow border panel design

The optimized design of panel adopts chip on film (COF) side bonding technology. Compared with the traditional COF surface bonding technology, COF is fixed to the side of glass by Ag glue, and connect with lead，which narrows the space required for COF bonding and reduces the panel border.

In addition to design optimization, the new panel solution has been optimized in polarizer laser cut process, Ag printer process, and side COF bonding process. In the end, we achieve the goal of reducing the border size from data pad (DP)/gate pad (GP)/ data pad opposition (DPO)/ gate pad opposition (GPO) = 1.2/0.8/1.2/0.8mm to 0.6/0.5/0.6/0.5mm (reduced by 50%/37%/50%/37%).

Combined with the optimized architecture of the module and the use of narrow border panel, the bezel width has been reduced to the 0.95mm+0.75mm=1.7mm, which is the narrowest bezel in the LCD video wall field, realizing a significant reduction of 45% compared to the traditional module bezel width (3.1mm→1.7mm, reduced by 1.4mm)

2.3 Tapes Design

The HNB video wall module uses adhesive tape to enhance its reliability and prevent panel skipping.

After the width reduction of panel border and bezel width, the risk of module reliability has increased. In the optimized architecture，high viscosity double-sided tape is used on the DP/GP side of the panel, which function is to restrict the movement of the panel better. And elastic tape (made of elastic material that can stretch under force) is used on the DPO/GPO side of the panel, which function is to not only fix the panel, but also prevent the COF from being pulled due to the expansion and contraction of the materials in the module during high and low temperature experiments.

By using the tapes mentioned above, the panel, Glass DP and BLU are connected to the bezel inner to fix as a whole. After the Bezel is locked with screws, the module components are tightly integrated, improving the strength of the module.

As shown in the table below, various reliability verification experiments were conducted on the new architecture product, and the results are all passed.

Table 2. Reliability testing project for new module architecture

Item			Condition	Result
Reliability verification Project	Mechanical	Packing Vibration	1.05Grms, 5~200Hz，X/Y/Z	Pass
	Operation	THO	50℃，80% RH，240hr	Pass
		HTO	60℃，240hr	Pass
		LTO	-5℃，240hr	Pass
	Storage	TST-1	-20℃~60℃ (Per 30min)，100 cycle	Pass
		THS	60℃，90%RH，240hr	Pass
		LTS	-20℃，240hr	Pass

The optimized architecture design ensures high reliability of the module while implementing narrow bezel design.

3. Design scheme for high picture quality

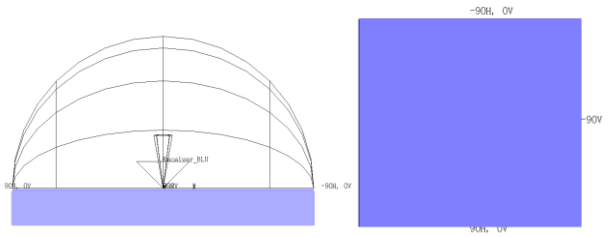
The HNB video wall module improves picture quality by optimizing the shape of the middle frame.

Traditional video wall products commonly suffer from the problem of dark edge of the module. It is mainly due to the obstruction of light at the edge of the module by the middle frame. Therefore, optimizing the shape of middle frame to allow more light to enter the edge of the module is the optimization direction to solve the problem of dark edge.

Picture quality optimization usually starts with optical software simulation optimization, followed by demo confirmation, and then imports into productization based on actual improvement effects.

3.1 Optical software simulation

Firstly, using LightTools optical simulation software, a simulation model is established based on the HNB video wall module design architecture, and parameters such as material and surface properties of each component are setting, as shown in the following figure.



Front view Top view

Figure 5. Establishment of Optical Simulation Model

Secondly, decompose the middle frame into three parts: top, upper, and bottom. Analyze the impact of shape and angle of the middle frame, the distance to the display area, the reflectivity of the surface of the middle frame, and the distance between the middle frame edge and AA on the picture quality at the edge of the module, as shown in the following figure [3].

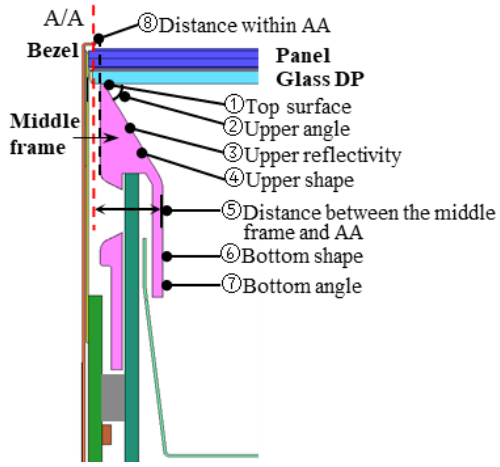


Figure 6. Schematic diagram of module section

Finally, LightTools software is used to simulate each parameter of the middle frame, obtaining the relationship between each parameter and the dark edge. Combined with the mold processing capability of the middle frame and the matching limit between structural components of the module, the optimal design value for optimizing the dark edge was obtained, as shown in the table below.

Table 3. Optimization of middle frame design parameters

Design parameters		Relationship with picture quality	Optimal design value
Middle frame	Top surface	The smaller top surface is better	R=0.3mm arc
	Upper angle	The larger angle is better	63 °
	Upper reflectivity	The higher reflectivity is better	86%
	Upper shape	Straight line is better than arc	Straight line
	Distance between the middle frame and AA	The smaller distance is better	5mm
	Bottom shape	Straight line is better than arc	Straight line
	Bottom angle	The larger angle is better	90 °
	Distance within AA	The smaller distance is better	0.3mm

Using the table above to design the optimal values, an optimized middle frame model is established in the software for simulation. The final simulation results are shown in the figure 7&8. Compared with the simulation results of the traditional design, it can be seen that the picture quality and brightness curve have been significantly improved, and the dark edge optimization scheme is effective.

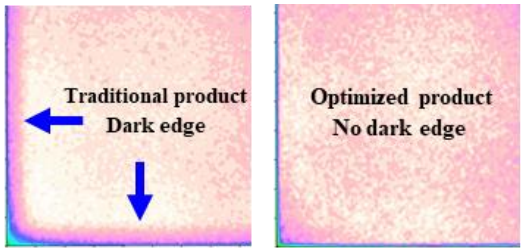


Figure 7. Comparison of simulation results between the traditional and optimized schemes

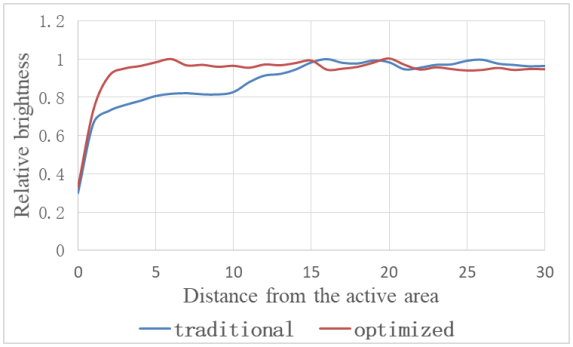


Figure 8. Comparison of brightness curve simulation results between the traditional and optimized schemes

3.2 The demo confirmation

Based on the simulation results of the middle frame design parameters, the demo assembly is completed. Comparison between the traditional scheme and the optimized scheme as shown in figure 9, it can be seen that the actual effects of the optimized scheme is consistent with the optical simulation, and the picture quality and brightness curve at the edge of the module are both optimized.

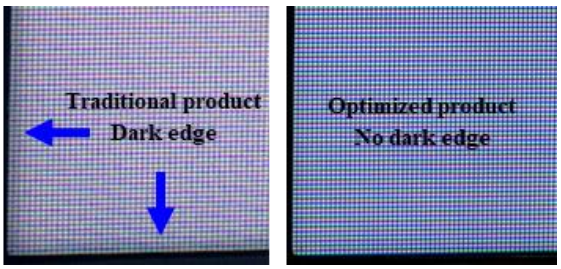


Figure 9. Comparison of actual effects between the traditional and the optimized schemes

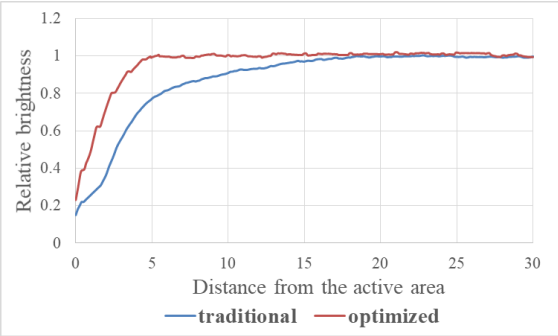
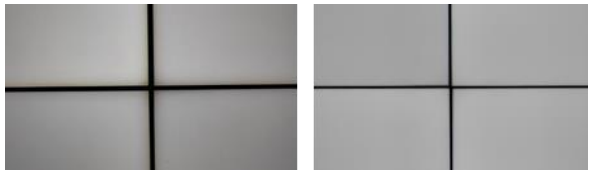


Figure 10. Comparison of actual effects brightness curve between the traditional and optimized schemes

4. Comparison of visual effects after splicing

At present, the HNB video wall product has been mass-produced and has received good feedback from the market and unanimous praise from user. Compared with the traditional product, there is a significant improvement in bezel width and picture quality, as shown in the visual effect of the 2 * 2 splicing module in the following figure.



Traditional Optimized

Figure 11. Comparison of visual effects between the traditional scheme and the optimized scheme after splicing

5. Conclusion

The solution of the HNB video wall module with high picture quality and high reliability is achieved through a new design architecture and optimized middle frame structure：

- The fully laminated solution of Glass DP and optical sheets can save the expansion space reserved for DP and optical sheets in the module, thereby narrowing the bezel width. At the same time, it has the advantage of improving module strength and preventing sheets wrinkling;
- The implementation of HNB module requires using panel and bezel with narrower borders;
- The combination design of high viscosity double-sided tape and elastic tape can not only limit the movement of the panel but also prevent damage to the COF caused by pulling, ensuring the reliability of the module;
- The optimized scheme of the middle frame shape can increase the amount of light entering the edge of the module, effectively solve the problem of dark edge of the module, and achieve perfect picture quality;
- Light Tools software can play a key role in the evaluation of picture quality improvement, enhancing the accuracy and efficiency of optimization scheme evaluation;

6. Impact

The design architecture of the HNB video wall module proposed in this paper provides reference significance for the design of narrow bezel LCD module in other products.

The simulation software method for optimizing the picture quality of the module and the optimization scheme for the design parameters of the middle frame provide design experience for the direct-type narrow bezel module.

7. References

[1] J.X. Sun, Video Wall Module architecture, display and electronic device [P], China: CN117456843A, 2024-01-26
[2] H.J Shi, Light diffusion plate, backlight module and display device [P], China: CN211856958U, 2020-11-03
[3] C.J. Fu, Display module and display device [P], China, Application Number: 202410015913.4