14-in. 3k2k LTPS-LCD with 120Hz Driving for Notebook

Ting Wang, Hongbo Zhou, Xiufeng Zhou, Junyi Li

Research and Development Division, XiaMen Tianma Microelectronics Co., Ltd.
No. 6999, Xiang'an West Road, Xiang'an District, Xiamen, China

Keywords: LTPS-LCD, 120Hz, High resolution, Notebook

Abstract
In recent years, with the rise of the e-sports industry, the proportion of game laptop with high frequency screen is increasing. Therefore high frequency plus high resolution is the inevitable trend. The high frequency and high resolution result in a reduction in charging time and a increment in loading. In this paper, a latest 14-in. 3k2k LCD with 120Hz driving for notebook with larger charging ability and lower loading was developed by Tianma Microelectronics Co.Ltd.

1. Background and objectives

In recent years, we can see that with the rise of the e-sports industry, more and more people have the enthusiasm to play computer games. It led to the development of the computer peripheral industry. Such as mechanical keyboards, e-sports mice, and e-sports displays. The survey data shows that the proportion of game laptop is increasing, and the trend of consumption upgrade is still obvious. The increase in entertainment requirements and performance requirements of the game players made the game sales account for 39.8% of the notebook sales, leading the growth of the overall sales of the notebook.

60Hz frames used to be a standard for constant game running. But as hardware performance improves, the performance of the game becomes more and more complex, the battle is more intense, and the fault tolerance rate is lower. When we run the current game to turn the angle of view, we can see that the game screen will become blurred or even tearing. Obviously, this can no longer meet the needs of e-sports players who have extremely high operational requirements for games. A 3k2k LCD with120Hz driving frequency for notebook and tablet was developed, which improve the drop frame phenomenon when quick operation in playing games.

2. Design and Results

2.1 Charging ability improving and uniform

The high frequency and high resolution result in a reduction in charging time and a increment in loading, which means the charging ability and route loading need to be developed. In this paper, 1:2 Demux panel driving system, TFT device characteristics increasing and Film layer loading decreasing are chosen for improving the charging ability and uniformity.

2.1.1 Panel driving system

Frame frequency double result in the charging time halving. In addition, the resolution increased from FHD to 3K2K will reduce the charging time further. The specific charging time are shown in Table 1. It can be found from the table 1, the CKH charging time of 120Hz 3K2K 1:3 Demux architecture is 0.6us, close to the limitation of charging time. In order to increase the CKH charging time, 1:2 Demux panel driving system is chosen shown on Figure 1, which can lead to 1us CKH charging time.

Table 1 Charging time demand of 120Hz and high resolution

	CKV charging time	CKH charging time
60Hz FHD 1:3Demux	14us	4us
60Hz 3k2k 1:3Demux	7us	1.8us
120Hz 3K2k 1:3Demux	2.95us	0.6us
120Hz 3K2k 1:2Demux	2.95us	1us

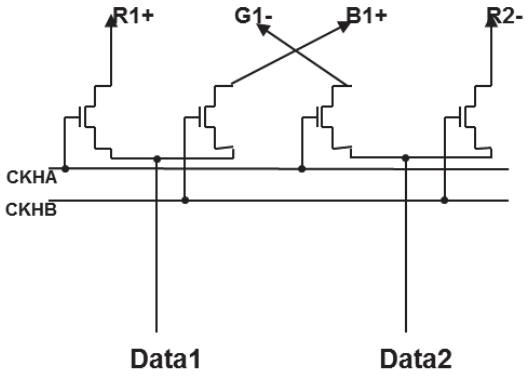

Figure 1. Schematic circuit diagram of 1:2 mux

2.1.2 TFT device characteristics

Besides the charging time, the TFT device characteristics also can improve the charging ability. We try to decrease the Vth to increase the Ion. As the simulation result shown on Figure 2, with the Vth increasing from 1 to 2.6, the charging ratio reduce from 99.7% to 97.7%. Only when the Vth is from 1.5 to 2.6, the decline of charging ratio is obvious. When the Vth decreased to 1.5, the changing of Vth has little meaning for charging. Which means the Vth is suitable for 1.5.

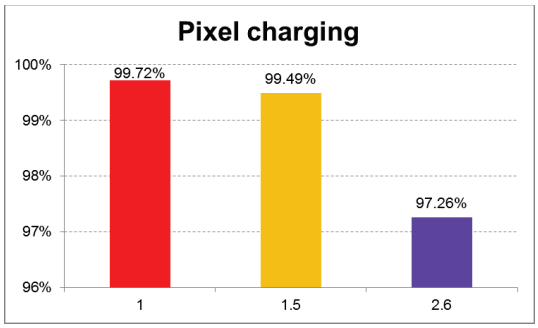

Figure 2. pixel charging of different Vth of TFT device

2.1.3 Route loading

In addition, route loading is an important impact factor for charging ability and charging uniformity. Since the thickness of PV is the most important impact factor of Capacitance of storage(Cst) and the Cst is the most important impact factor of pixel charging. In order to improve the pixel charging ratio, we try to increase the thickness of PV. As the simulation result showed on Figure 3, we can see with the increasing of PV thickness, the pixel charging ratio is increasing as expected.

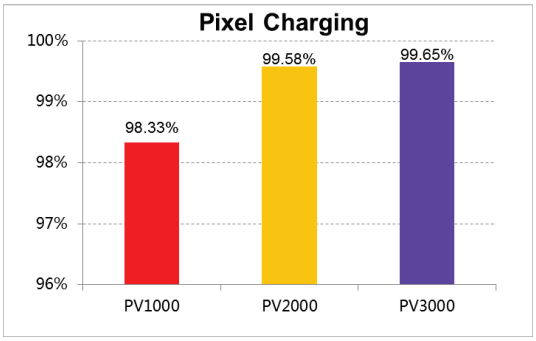

Figure 3. Pixel charging of different thickness of PV

Since the thickness of M1 is related to the delay difference between Gout and Gend, we try to increase the thickness of M1 for charging uniformity. As the simulation result showed on Figure 4, we can see with the increasing of M1 thickness, the difference between Gout and Gend is decreasing as expected.

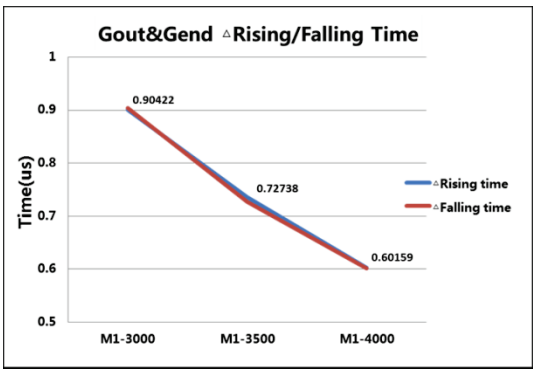

Figure 4. Rising/falling time of different thickness of M1

2.2 Main block diagram and V-line mura issue

Due to the high resolution and 14-in., the data route will be more and long, which means the length and resistance of data route will have big difference between far IC area and near IC area. In order to reduce the charging difference between far IC area and near IC area, the 4 IC solution has been chose shown on Figure 5. As a result, the data charging of 4 IC solution is much higher than 1 IC solution at far IC area by simulation shown on Figure 6.

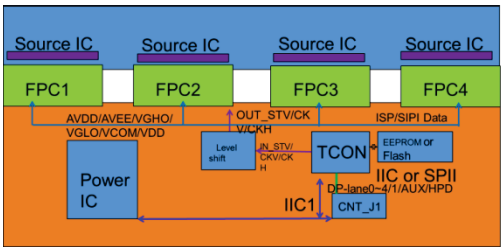

Figure 5. Main block diagram with 4 IC solution

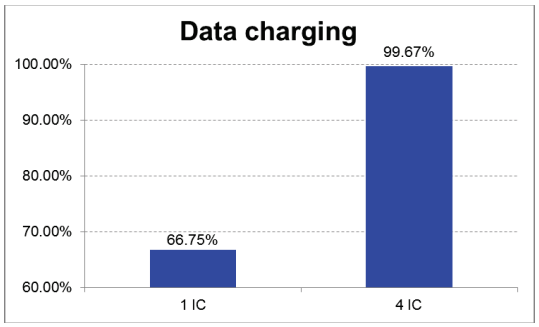

Figure 6. Data charging difference of 4 IC solution and 1 IC solution

Due to the collocation of 4 IC solution and NMOS driving, the adjacent source line voltage of adjacent different IC will be different because the coupling by clock signal is different which related to timming setting and couple capacitance. It results in the V-line mura issue shown on Figure 7.

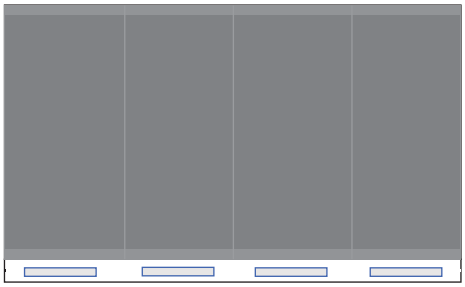

Figure 7. The phenomenon of V-line mura issue

Through the analysis and simulation of IC setting and the resistance and capacitance of clock signal route, we choose a best match IC timming setting and design a shielding structure which could protect the source signal from the coupling influence of clock signal and solve the V-line mura issue.

2.3 New liquid crystal material for quick response

The response time of LCD is decided to the flip speed of electric field and the response time of liquid crystal. The flip speed of electric field is decided to input signal which is fixed by IC and delay of loading which is mentioned in the previous section. In this paper, we try to use a new liquid crystal material to achieve the quick response shown on Table 2.

Table 2. The response time contrast of 60Hz and 120Hz

		60Hz	120Hz
Response Time (ms)	Ton + Toff : Typmax26ms	22ms	14ms
	GTG <35ms	27ms	16ms

2.4 Results

To solve the risk items, we did some simulation analysis and experimental verifications. With concerted efforts by R&D departments, we developed a 14-in. 3k2k LCD with 120Hz driving finally shown in Table 3 and Figure 8. From the actual effect, the blur phenomenon of 120Hz is much better than 60Hz shown on Figure 9. And the response time can achieve to 16ms. The luminance of white pattern is 450 cd/m² which is as the same level as 60Hz LCD. And in terms of power consumption, in general, the driving power consumption of LCDs is proportional to the driving frequency [2].As a result, 120Hz is 1.5 times higher than 60Hz. In order to reduce power consumption, we have done some study by other team.

Table 3. The design specifications of 14" 3K2K 120Hz

Display Technology	LTPS IPS
Resolution(pixel)	3000×2000
Border(mm)	1.8
Luminance(cd/m²)	450
Contrast Ratio	1500:01:00
Viewing Angle(U/D/L/R)	88/88/88/88
PPI	259
Frequency	120Hz
Response Time(GTG)	16ms
Interface	eDP1.4
NTSC	96%
Application	Notebook / Ultrabook

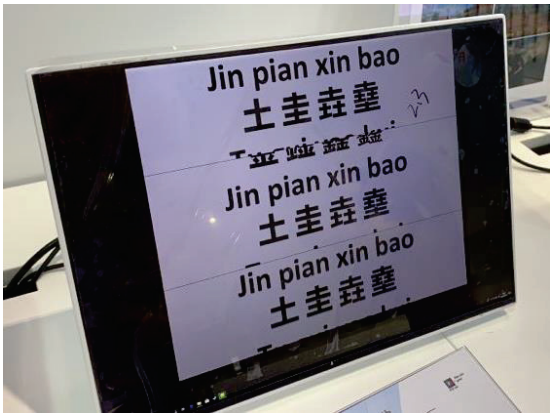

Figure 8. The actual display

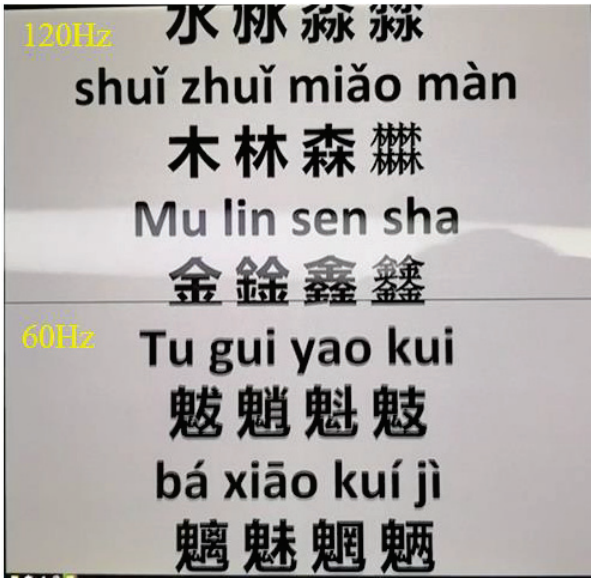

Figure 9. The actual display of 60Hz and 120Hz

The reliability and ESD performance could pass the major notebook manufacturers specification.

3. Conclusion

A 14-in. 3k2k LCD with 120Hz Driving for notebook has been developed and can mass produce. It is the first time to develop a high resolution plus high frequency LCD, which is industry leader. It also lay a solid foundation for the subsequent 4K 144Hz and even higher frequency panel development.

5. References

[1] Ryutaro Oke, Takashi Nakai, Junichi Maruyama, Daisuke Kajita, Kaori Miyazaki, Masahiro Ishii, and Hideki Matsukawa, “World’s First 55-in. 120Hz-Driven 8k4k IPS-LCDs with Wide Color Gamut”, SID, 2015.

[2] K. Tsuda, N. Kimura and S. Mizushima, “Ultra low power consumption technologies for mobile TFT-LCDs”, IDW 2002.

[3] Nam H , Oh J , Shin B H , et al. 61.4: Novel Impulsive Driving Schemes Using Frame Rate Doubling for 120Hz LCD Panels[J]. Sid Symposium Digest of Technical Papers, 2012.

[4] He H , Janssen J G , Bellers E . Low cost LCD panel frame rate doubling by applying Motion Controlled Dynamic Frame Insertion[C]. International Conference on Consumer Electronics. IEEE, 2009.

[5] Long-Qiang Shi, Yi-Fang Chou, Ying-Chun Zhao, Shu-Jhih Chen, Feng Zhao, Shi-Min Ge, Zeng-Jie Kong, Feng-Cheng Xu, Peng Du, Chung-Yi Chiu, Ray Lin. The World’s First 85-in 8K×4K 120Hz VA-LCD Driven by BCEIGZO GOA. IDW 2002.