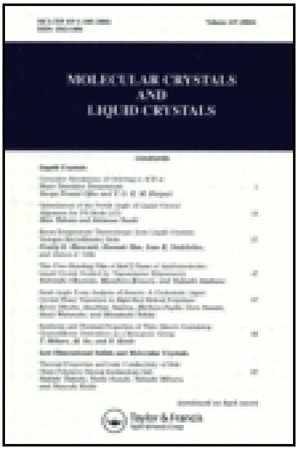

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

Field Sequential Fullcolor LCDs using FLC Technology

Masahiro Shikada [a], Hirokazu Furue [a], Taiju Takahashi [b] & Shunsuke Kobayashi [a]

[a] Liquid Crystal Institute and Graduate School of Engineering Science, Science University of Tokyo in Yamaguchi, 1-1-1 Daigaku-dori, Onoda, Yamaguchi, 756-0884, JAPAN

[b] Faculty of Engineering, Kogakuin University, 2665-1, Nakano-cho, Hachioji, Tokyo, 192-0015, JAPAN

Version of record first published: 24 Sep 2006

To cite this article: Masahiro Shikada, Hirokazu Furue, Taiju Takahashi & Shunsuke Kobayashi (2001): Field Sequential Fullcolor LCDs using FLC Technology, Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals, 368:1, 223-229

To link to this article: http://dx.doi.org/10.1080/10587250108029950

Mol. Cryst. and Liq. Cryst., 2001, Vol. 368, pp. 223-229
Reprints available directly from the publisher
Photocopying permitted by license only

Field Sequential Fullcolor LCDs using FLC Technology

MASAHIRO SHIKADA[a], HIROKAZU FURUE[a], TAIJU TAKAHASHI[b] and SHUNSUKE KOBAYASHI[a]

[a]*Liquid Crystal Institute and Graduate School of Engineering Science, Science University of Tokyo in Yamaguchi, 1-1-1 Daigaku-dori, Onoda, Yamaguchi 756-0884, JAPAN and* [b]*Faculty of Engineering, Kogakuin University, 2665-1, Nakano-cho, Hachioji, Tokyo 192-0015, JAPAN*

We constructed field sequential fullcolor (FS-FC) LCDs using two kinds of mesogenic polymer stabilized FLCs; the first one is the Half V type (HV-FLCD) that exhibits asymmetric EO performance and the other is the V type (V-FLCD) exhibiting symmetric EO performance. As back a light system, we used a 2D array of red, green, and blue LEDs. We compared the performance of these two types of FS-FC-LCDs using two different kinds of FLCDs. It is concluded that a FS-FC LCD using a HV response may yield higher luminance at the white (light) state than that uses a V-FLCD.

Keywords: FLCD; polymer stabilization; field sequential fullcolor LCD

1. INTRODUCTION

Comparing to the conventional color LCDs that use color filters, field sequential fullcolor (FS-FC) LCDs have several superiories in such as high luminance capability due to color fililterless, the high resolution, and the simplicity in the production compare.

In the early age, FS-FC displays using LCD technologies were produced by combining a resolution monochrome(black and white) CRTs with LCD cells such as a ECB cell[1] and π cells[2], and also by combining a optical fiber coupled three R, G, and B CRT tubes and a fast response TN-LCD with 2μm thich and FLCD.[3] The first flat panel type FS-FC-LCDs were demonstrated by Kobayashi's group, where a 2D array of color LEDs were used as a sequential back light systems together with fast TN-LCD(with 2μm thick) and FLCD, where the thin TN-LCD cell exhibits response time of several ms.[4] After that recently, several research groups reported FS-FC LCDs adopting the following combinations: color LEDs and a reflective micro FLCD[5]; cold cathode tube and an OCB cell[6]; LEDs and a bistable FLC cell[7]; LEDs and a PS-HV-FLCD cell[8] ; and LEDs and a HV-FLCD[9]. Here in the present paper, we report a FS-FC-LCD using the combination of LEDs and a PS-V-FLCD in comparison with that uses a PS-HV-FLCD.

In regarding the development of FLCD technology, it has been being done in the following manners: SSFLCD was reported by Clark and Lagerwall in 1980[10]; Fukuda's group reported an antiferroelectric LCD exhibiting double hysteresis[11]; FLCDs that exhibit V-shape EO response without polymer stabilization, which is called "intrinsic type" in this papers, were reported by several groups such as CASIO, University of Colorado group, and TIT group[12,13,14]. An intrinsic type HV-FLCD was reported by Asao et al[9]. Mesogenic polymer stabilized (MPS) HV-FLCD[15], and MPS-V-FLCD[16] were reported by the present authors' group. Polymer stabilized FLCs are refered to as "extrinsic type" in this paper.

In this present paper we report addressing schemes, a consideration the luminance, and the performance of two FS-FC-LCDs using PS-HV-FLCD and PS-V-FLCD.

2. Characteristics of PS-HV-FLCD and PS-V-FLCD compared to other FLCDs

On Table 1, we compare characteristics of extrinsic type HV-FLCD and V-FLCD developed by our group in comparison with intrinsic type

FLCDs. It is shown that the extrinsic PS-FLCDs have response times of around 100μs or less, owing to the function of polymer stabilization, and they are free from the restriction of Ps values when they are driven with TFT. These favorable features will be taken advantage for implementing a field sequential fullcolor (FS-FC) LCD.

TABLE 1. Comparison of FLC Family Technology

Intrinsic	τ_r (μs)	τ_f (μs)	Ps (nC/cm^2)	ϕ (deg.)	Firms
SS-FLCD	100	∞	5~200	45	UC, Chalmers UT
V-FLCD	100~1000	100~1000	100~200	±30	Casio, TIT, UC, Sony, SUT-Y
HV-FLCD	400	300	5~10	45	Canon, Chisso, SUT-Y
Extrinsic(PS)	τ_r (μs)	τ_f (μs)	Ps (nC/cm^2)	ϕ (deg.)	Firms
V-FLCD	100	60	5~10	±27	SUT-Y, Kyocera, DIC
HV-FLCD	100	100	5~10	45	SUT-Y, DIC

3. System consideration of FS-FC-LCD:

In Fig.1 (a) and (b), two timig charts are shown: on the left, the scheme for a system using HV-FLCD is shown as Fig.1(a), and on the right the case where V-FLCD is used (Fig.1(b)), together with formulas giving luminance level. In this figure, T_F stands for the frame periode(we take T_F=16.7ms, 60Hz), and Ts is the scanning periode. The ratio $\tau_{LC}/(T_F/3) \fallingdotseq 2\times10^{-2}$, where τ_{LC} is the response time of FLCD. Therefore the effect of the response time is negligible for drawing such figures as shown Fig.1, when we use FLCDs whose response time is around 100μs. In our case the light on time for one color $\tau_{BL}/(T_F/3)=1$ or 0.5 depending on the use of HV or V-FLCD. On the other hand, when a nematic LCD is used $\tau_{LC}/(T_F/3)=0.36$ where τ_{LC} =2ms; in this case, it is difficult to neglect the effect of τ_{LC} and , in turn, lighting periode of the back light becomes short such that $\tau_{BL}/(T_F/3)\fallingdotseq0.44$.[17] These values are summarized on Table2.

Now, we discuss the luminance levels of FS-FC-LCDs using HV-FLCD and V-FLCD. The formulas expressing these quantities are also shown in Fig.1, where ϕ stands for the deflection angle as individually shown Fig.1 (a) and (b). Fig.2 shows the relationship between the optical intensity I and the deflection angle ϕ both for HV-FLCD and V-FLCD. Normally I_{HV} is larger than I_V, but I_V is nearly equal I_{HV} only when $\phi = 45°$ and Ts = 1ms, which corresponds the case where the frame rate is 162Hz.

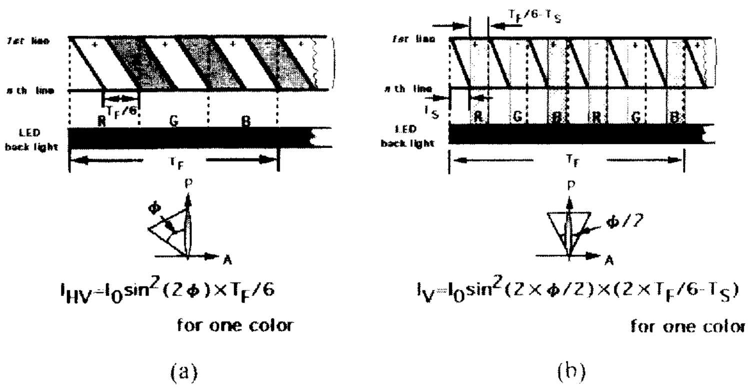

FIGURE 1 Timing charts of FS-FC-LCDs

TABLE 2

	τ_{LC}	$\tau_{LC}/(T_F/3)$	$\tau_{BL}/(T_F/3)$
Nematic LCD	2ms	0.36	0.44
FLCD	100μs	0.02	1 or 0.5

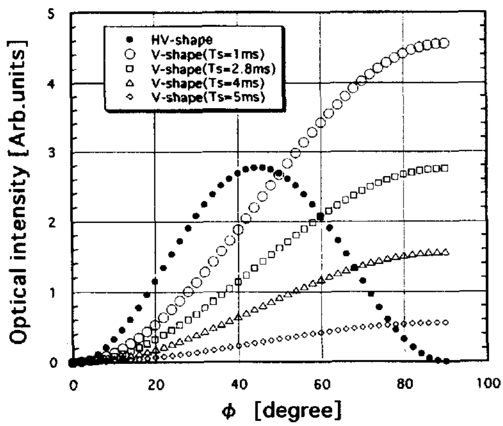

FIGURE 2 Luminance level of FS-FC-LCD using HV-FLCD and V-FLCD

4. Experimental demonstrations of FS-FC-LCDs

We have constructed three FS-FC-LCD sets as follows: A) 8 color bars in $3\times 4cm^2$ display area that displays uniform colors, graded colors and moving bars; B) fixed electrodes format having 160 electrode connections with area of $11\times 7.5cm^2$; and C) VGA TFT matrix with $5\times 4cm^2$. Figure 3 demonstrates letters and color bars displayed on the screen of the FS-FC-LCD type(B). Research on the type (C) LCD is now underway.

We investigated the performance of these displays; and as a preliminary result, it is shown the display type A) using HV-FLCD yield higher luminance that using V-FLCD by the factor of 2 particularly when Ts=2.8ms($Ts=T_F/6$) and, when we used the same FLC material. However, the cone angle or deflection angle strongly depends on the FLC material, so that it is that better FLC material will be synthesized.

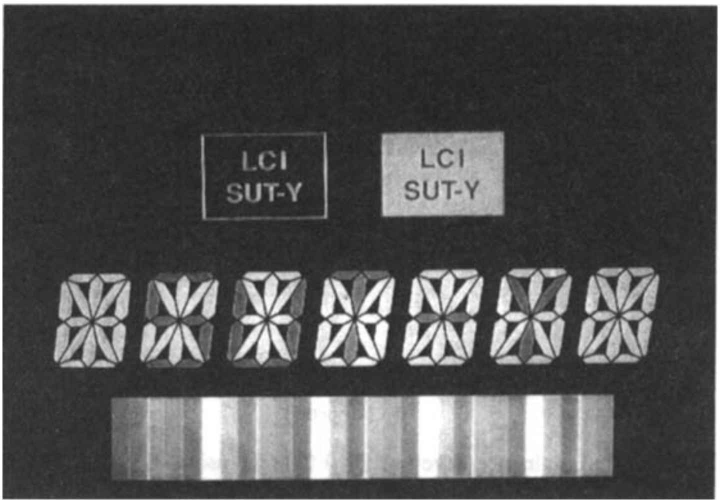

FIGURE 3 An example of field sequential color LCD using ferroelectric liquid crystal

5. Concluding summary

We have developed FLCDs exhibiting Half V (asymmetric) and V shape (symmetric) EO performance by adopting sidechain mesogenic polymer stabilization. They are referred to as extrinsic type HV-FLCD and V-FLCD. We used these two kinds of FLCDs to construct field sequential fullcolor LCD by combining with a 2D array of RGB color LEDs. We take the frame rate at 60Hz and investigated attainable luminance depending on the difference of HV and V characteristic FLCDs. When we use the same FLC material; the optimum deflection angle is $\phi = 45°$ for HV-FLCD; while in the V-FLCD $\phi = 22.5°$. This difference gives rise to the difference in the luminance, and it is shown that a FS-FC LCD using HV-FLCD produces higher luminance than that using V-FLCD. However, if it is possible to use better FLC material that gives $\phi > \pm 22.5°$, say $\pm 40°$, then a system using V-FLC becomes more promising one.

Acknowledgments
This research was done under the contract of JSPS-RFTF 98R14201.

References

[1] I. Shanks: Electronic Letters, **10**, 90 (1974); M.G. Clark and I. Shanks: 1982 SID Digest of Tech. Papers, 172 (1982).
[2] R. Vatne, P.A. Johnson, Jr., and P.J. Bos: 1983 SID Digest of Tech. Papers, 28 (1983); P.J. Bos, P.A. Johnson, Jr., and K.R. Koehler-Bern: 1983 Digest of Tech. Papers, 30 (1983); P.J. Bos, T. Buzak, and R. Vatne: Eurodisplay 84, 7 (1984).
[3] H. Hasebe and S. Kobayashi: 1985 SID Digest of Tech. Papers, 81 (1985).
[4] T. Tanaka, H. Hasebe, and S. Kobayashi: Proc. Japan Display 86, 360 (1986).
[5] M.D. Wanda, W.N. Thurmes, R.T. Vohra, and K.M. More: 1996 SID Digest of Tech. Papers, **27** 157 (1996); A. Mochizuki: O plus E **20** 787 (1998).
[6] T. Uchida, K. Saitoh, T. Miyashita, and M. Suzuki: Record of IDRC 97 37 (1997).
[7] T. Yoshihara, Y. Kiyota, H. Shiroto, T. Makino, and H. Inoue: Mol. Cryst. Liq. Cryst. **331** 217 (1999).
[8] T. Takahashi, H. Furue, M. Shikada, N. Matsuda, T. Miyama and S. Kobayashi: Jpn. Appl. Phys. **38**, L534 (1999).
[9] Y. Asao, T. Togano, M. Terada, T. Moriyama, S. Nakamura and J. Iba: Jpn. Appl. Phys. **38**, 5977 (1999).
[10] N.A. Clark and S.T. Lagerwall: J. Appl. Phys. **36**, 899 (1980).
[11] A.D.L. Chandani, Y. Ouchi, H. Takezoe and A. Fukuda: Jpn. J. Appl. Phys. **27**, L276 (1988).
[12] A. Fukuda: Proc. 15th IDRC (Asia Display '95) 65 (1995); S. Inui, N. Iimura, T. Suzuki, H. Iwane, K. Miyachi, Y. Takanishi, H. Takezoe and A. Fukuda: J. Mater. Chem. **6**, 67 (1996).
[13] T. Yoshida, T. Tanaka, J. Ogura, H. Wakai and H. Aoki: 1997 SID Digest of Tech. Papers **28**, 841; T. Tanaka: Jpn patent 194, 623 [94, 194, 623].
[14] P. Rudquist, J.P. F Lagerwall, M. Buivydas, F. Gouda, S.T. Lagerwall, R.F. Shao, D. Coleman, S. Bardon, D.R. Link, T. Bellini, J.E. Maclennan, D.M. Walba and N.A. Clark: 1999 SID Digest of Tech. Papers **30**, 409 (1999).
[15] H. Furue, T. Miyama, Y. Iimura, H. Hasebe, H. Takatsu, and S. Kobayashi: Jpn. J. Appl. Phys. **36** L1517 (1997); H. Furue, T. Takahashi and S. Kobayashi: Jpn. Appl. Phys. **38**, 5660 (1999).
[16] Y. Miyazaki and S. Kobayashi: 18th ILCC 27M-6-O; to be published in Mol. Cryst. Liq. Cryst.
[17] N. Koma, T. Miyashita, T. Uchida, N. Mitani: AM-LCD 2000 Digest of Tech. Papers 65 (2000).