US006727874B2

(12) **United States Patent**
Okuzono

(10) **Patent No.: US 6,727,874 B2**
(45) **Date of Patent: Apr. 27, 2004**

(54) **DRIVING CIRCUIT AND DRIVING METHOD OF COLOR LIQUID CRYSTAL DISPLAY, AND COLOR LIQUID CRYSTAL DISPLAY DEVICE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 249 days.

(21) Appl. No.: **09/988,189**

(22) Filed: **Nov. 19, 2001**

(65) **Prior Publication Data**

US 2002/0060656 A1 May 23, 2002

(30) **Foreign Application Priority Data**

Nov. 20, 2000 (JP) 2000-353427

(51) **Int. Cl.**[7] **G09G 3/36**
(52) **U.S. Cl.** **345/89**; 345/89; 345/690; 349/34
(58) **Field of Search** 345/88, 89, 98, 345/690, 208, 210, 211, 100; 349/34

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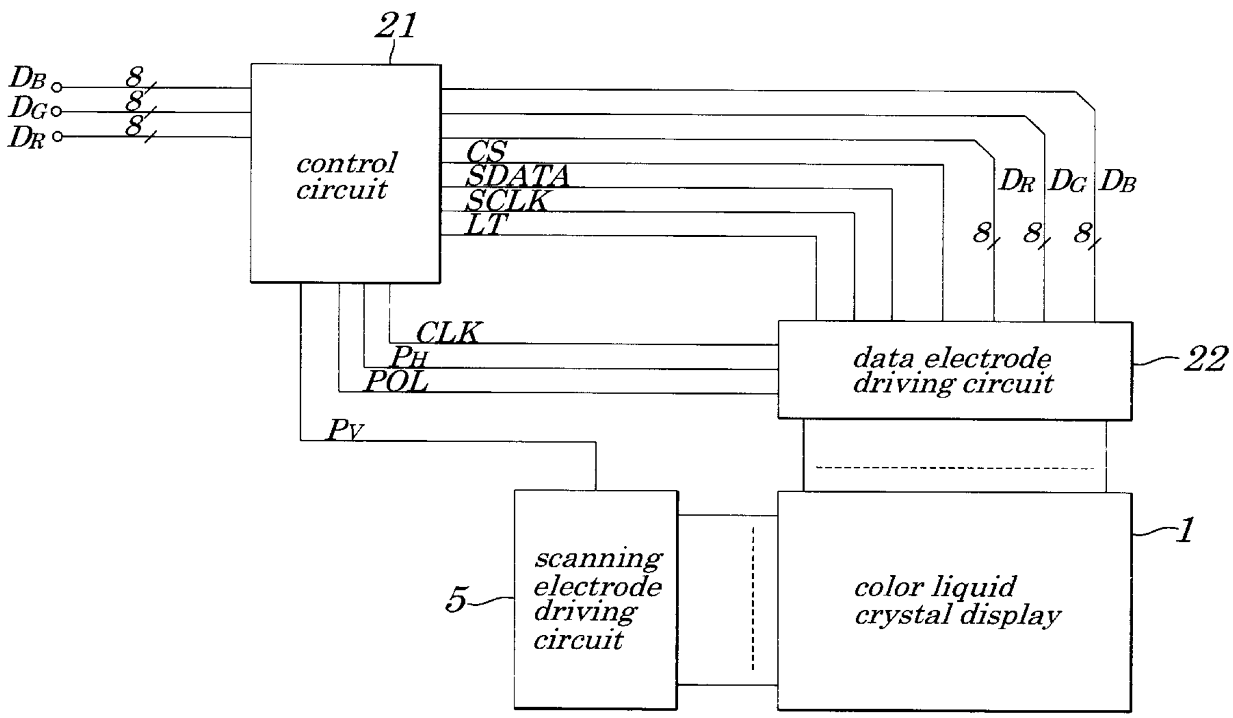
(74) *Attorney, Agent, or Firm*—Foley & Lardner

(57) **ABSTRACT**

A driving circuit of a color liquid crystal display is provided which is capable of reducing a substrate packaging area and using a common substrate or TCP (Tape Carrier Package) even when a resolution and/or the number of gray scale voltages that the color liquid crystal display provides are different, which enables the substrate, TCP, and a display device to be fabricated at low costs. In the driving circuit of the color liquid crystal display, a data electrode driving circuit produces gray scale voltages corresponding to gray scale voltage characteristics based on serial data made up of gray scale information and gray scale voltage information.

12 Claims, 17 Drawing Sheets



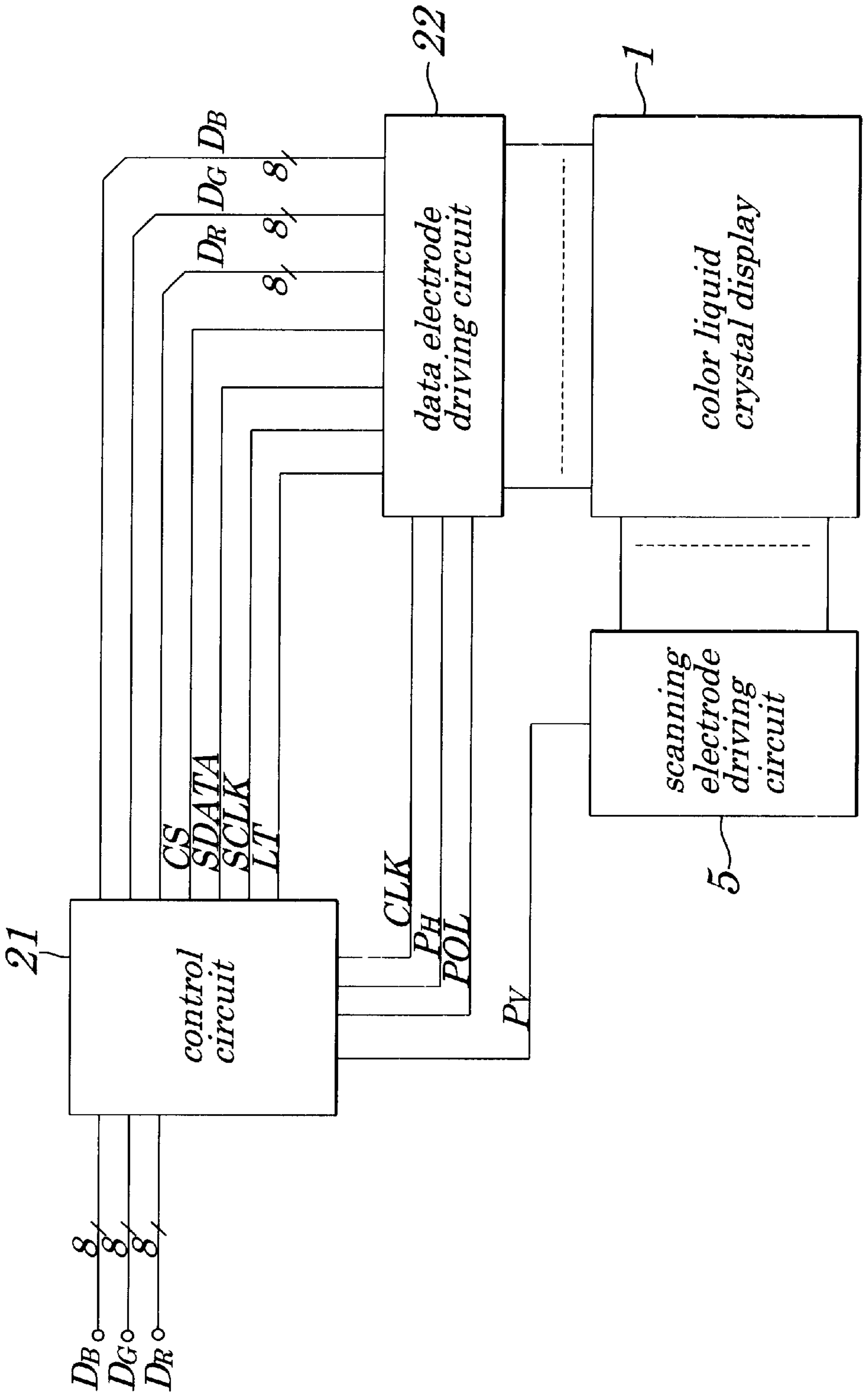

control circuit
data electrode driving circuit
color liquid crystal display
scanning electrode driving circuit
21
22
1
5
CS
SDATA
SCLK
LT
CLK
PH
POL
PV
DB
DG
DR
8
8
8
DB
DG
DR
8
8
8

FIG.1

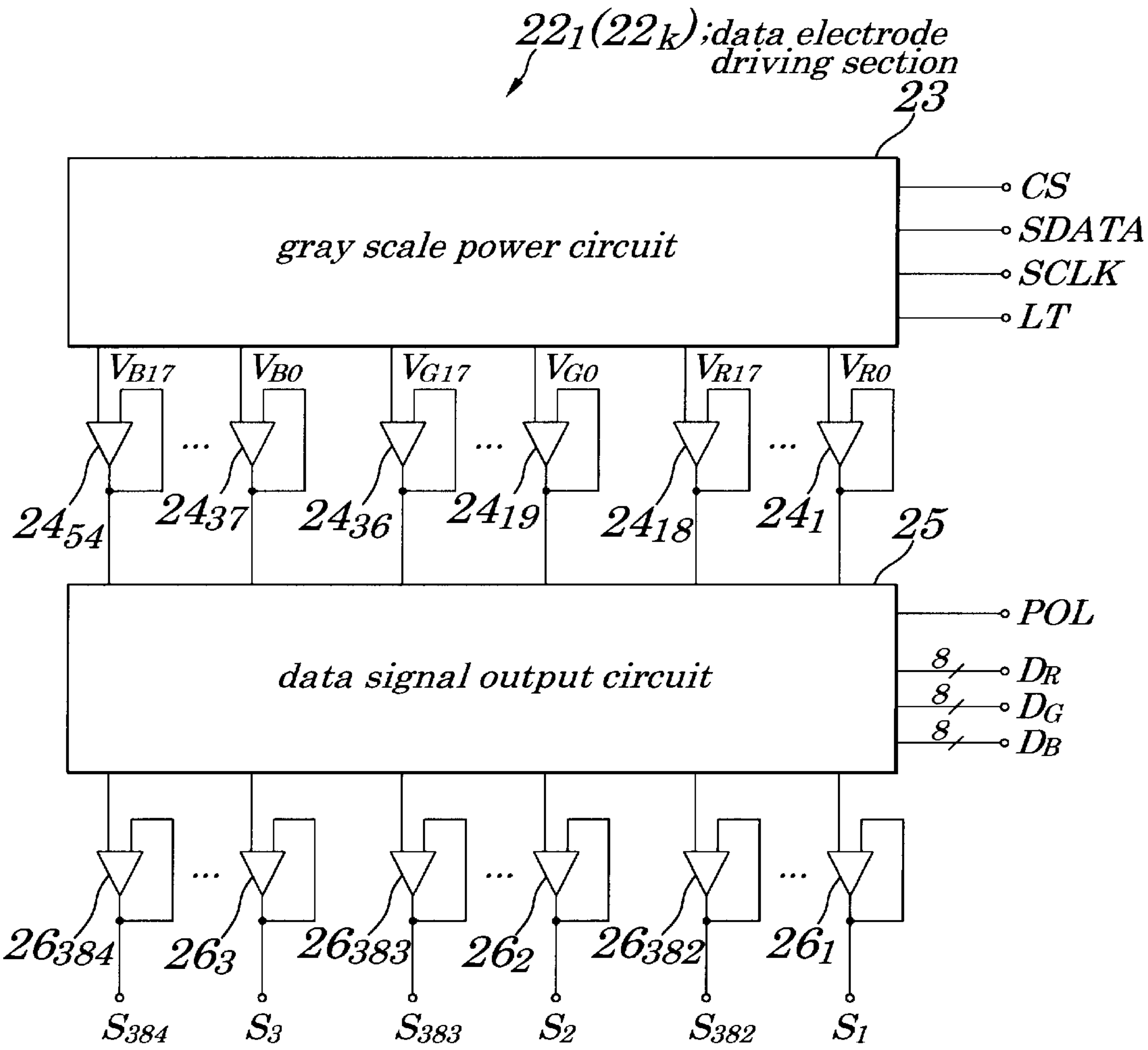
FIG.2

gray scale information						channel
A5	A4	A3	A2	A1	A0	
0	0	0	0	0	0	Ch R0
0	0	0	0	0	1	Ch R1
0	0	0	0	1	0	Ch R2
0	0	0	0	1	1	Ch R3
0	0	0	1	0	0	Ch R4
0	0	0	1	0	1	Ch R5
0	0	0	1	1	0	Ch R6
0	0	0	1	1	1	Ch R7
0	0	1	0	0	0	Ch R8
0	0	1	0	0	1	Ch R9
0	0	1	0	1	0	Ch R10
0	0	1	0	1	1	Ch R11
0	0	1	1	0	0	Ch R12
0	0	1	1	0	1	Ch R13
0	0	1	1	1	0	Ch R14
0	0	1	1	1	1	Ch R15
0	1	0	0	0	0	Ch R16
0	1	0	0	0	1	Ch R17
0	1	0	0	1	0	Ch G0
0	1	0	0	1	1	Ch G1
0	1	0	1	0	0	Ch G2
0	1	0	1	0	1	Ch G3
0	1	0	1	1	0	Ch G4
0	1	0	1	1	1	Ch G5
0	1	1	0	0	0	Ch G6
0	1	1	0	0	1	Ch G7
0	1	1	0	1	0	Ch G8
0	1	1	0	1	1	Ch G9
0	1	1	0	0	0	Ch G10
0	1	1	1	0	1	Ch G11
0	1	1	1	1	0	Ch G12
0	1	1	1	1	1	Ch G13
0	1	1	1	0	0	Ch G14
1	0	0	0	0	1	Ch G15
1	0	0	0	1	0	Ch G16
1	0	0	0	1	1	Ch G17
1	0	0	1	0	0	Ch B0
1	0	0	1	0	1	Ch B1
1	0	0	1	1	0	Ch B2
1	0	0	1	1	1	Ch B3
1	0	1	0	0	0	Ch B4
1	0	1	0	0	1	Ch B5
1	0	1	0	1	0	Ch B6
1	0	1	0	1	1	Ch B7
1	0	1	1	0	0	Ch B8
1	0	1	1	0	1	Ch B9
1	0	1	1	1	0	Ch B10
1	0	1	1	1	1	Ch B11
1	1	0	0	0	0	Ch B12
1	1	0	0	0	1	Ch B13
1	1	0	1	1	0	Ch B14
1	1	0	1	1	1	Ch B15
1	1	0	1	0	0	Ch B16
1	1	0	1	0	1	Ch B17

FIG. 3

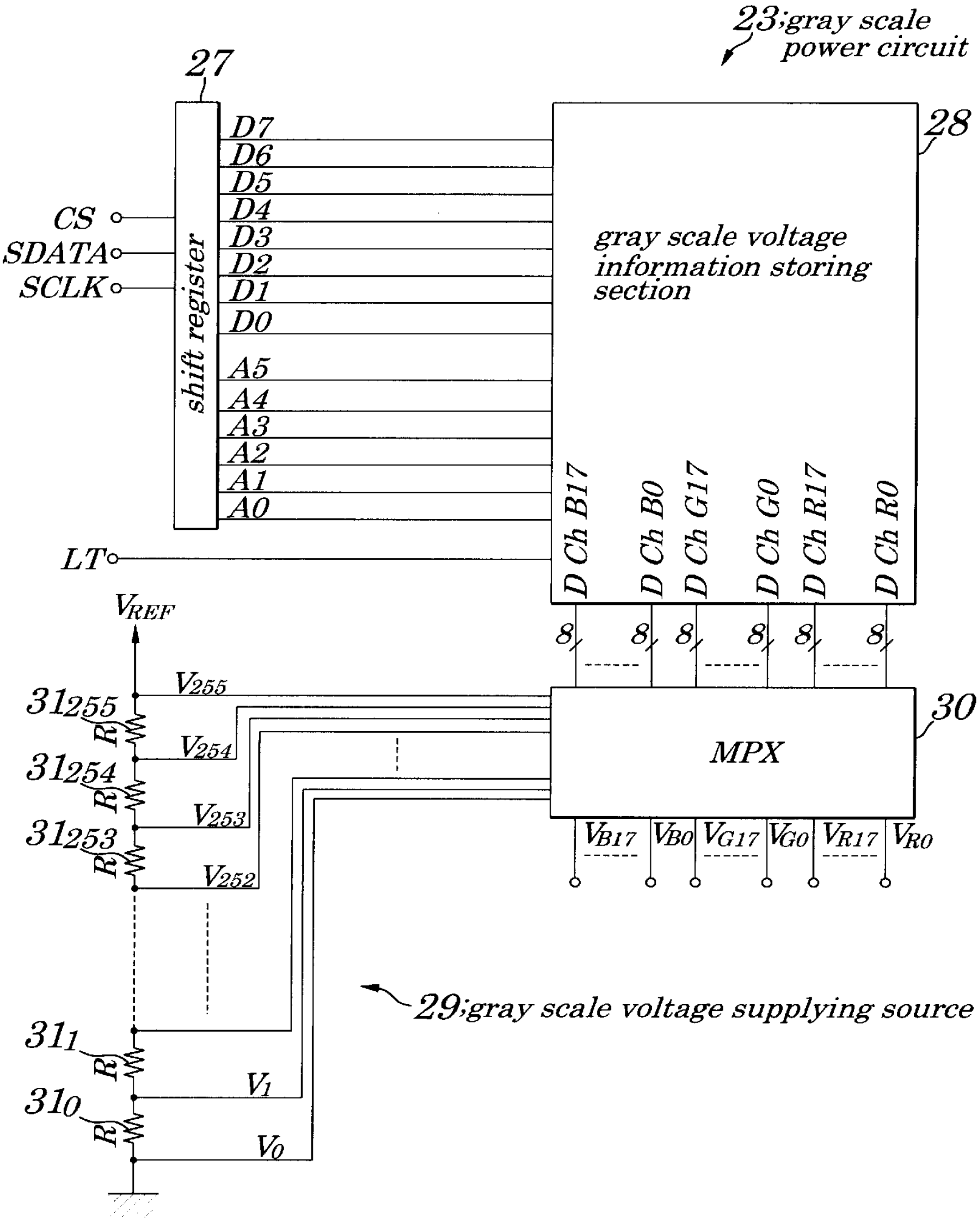
gray scale voltage information								gray scale voltage
D7	D6	D5	D4	D3	D2	D1	D0	
0	0	0	0	0	0	0	0	V_0
0	0	0	0	0	0	0	1	V_1
0	0	0	0	0	0	1	0	V_2
0	0	0	0	0	0	1	1	V_3
0	0	0	0	0	1	0	0	V_4
0	0	0	0	0	1	0	1	V_5
0	0	0	0	0	1	1	0	V_6
0	0	0	0	0	1	1	1	V_7
0	0	0	0	1	0	0	0	V_8
0	0	0	0	1	0	0	1	V_9
0	0	0	0	1	0	1	0	V_{10}
0	0	0	0	1	0	1	1	V_{11}
0	0	0	0	1	1	0	0	V_{12}
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
1	1	1	1	0	0	1	1	V_{243}
1	1	1	1	0	1	0	0	V_{244}
1	1	1	1	0	1	0	1	V_{245}
1	1	1	1	0	1	1	0	V_{246}
1	1	1	1	0	1	1	1	V_{247}
1	1	1	1	1	0	0	0	V_{248}
1	1	1	1	1	0	0	1	V_{249}
1	1	1	1	1	0	1	0	V_{250}
1	1	1	1	1	0	1	1	V_{251}
1	1	1	1	1	1	0	0	V_{252}
1	1	1	1	1	1	0	1	V_{253}
1	1	1	1	1	1	1	0	V_{254}
1	1	1	1	1	1	1	1	V_{255}

FIG.4



22₁(22k);data electrode driving section
23
gray scale power circuit
CS
SDATA
SCLK
LT
VB17
VB0
VG17
VG0
VR17
VR0
24₅₄
24₃₇
24₃₆
24₁₉
24₁₈
24₁
25
data signal output circuit
POL
8
DR
8
DG
8
DB
26₃₈₄
26₃
26₃₈₃
26₂
26₃₈₂
26₁
S384
S3
S383
S2
S382
S1

FIG.5


23;gray scale power circuit
27
shift register
CS
SDATA
SCLK
D7
D6
D5
D4
D3
D2
D1
D0
A5
A4
A3
A2
A1
A0
LT
28
gray scale voltage information storing section
D Ch B17
D Ch B0
D Ch G17
D Ch G0
D Ch R17
D Ch R0
8
30
MPX
VB17
VB0
VG17
VG0
VR17
VR0
VREF
31255
31254
31253
311
310
R
V255
V254
V253
V252
V1
V0
29;gray scale voltage supplying source

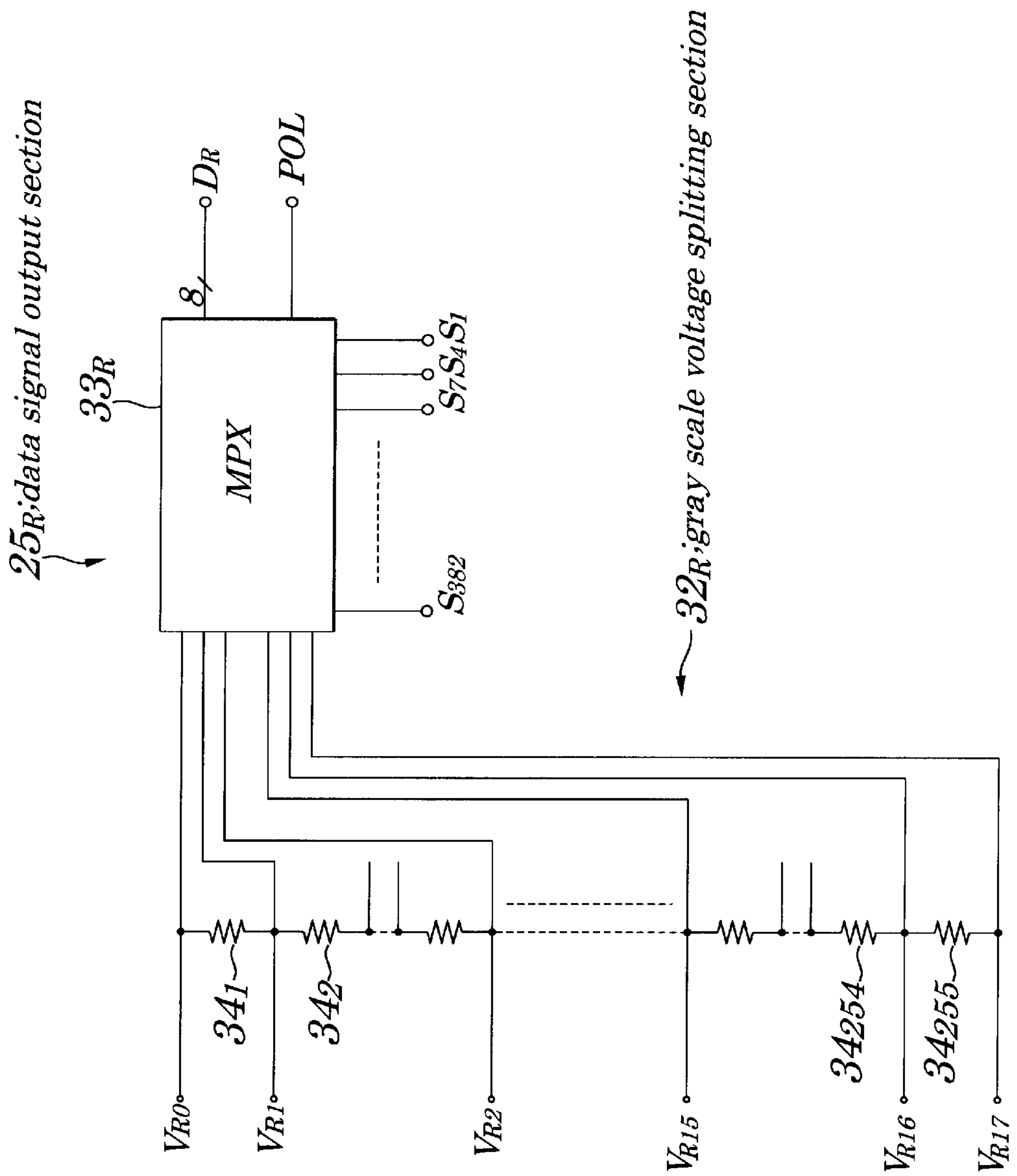
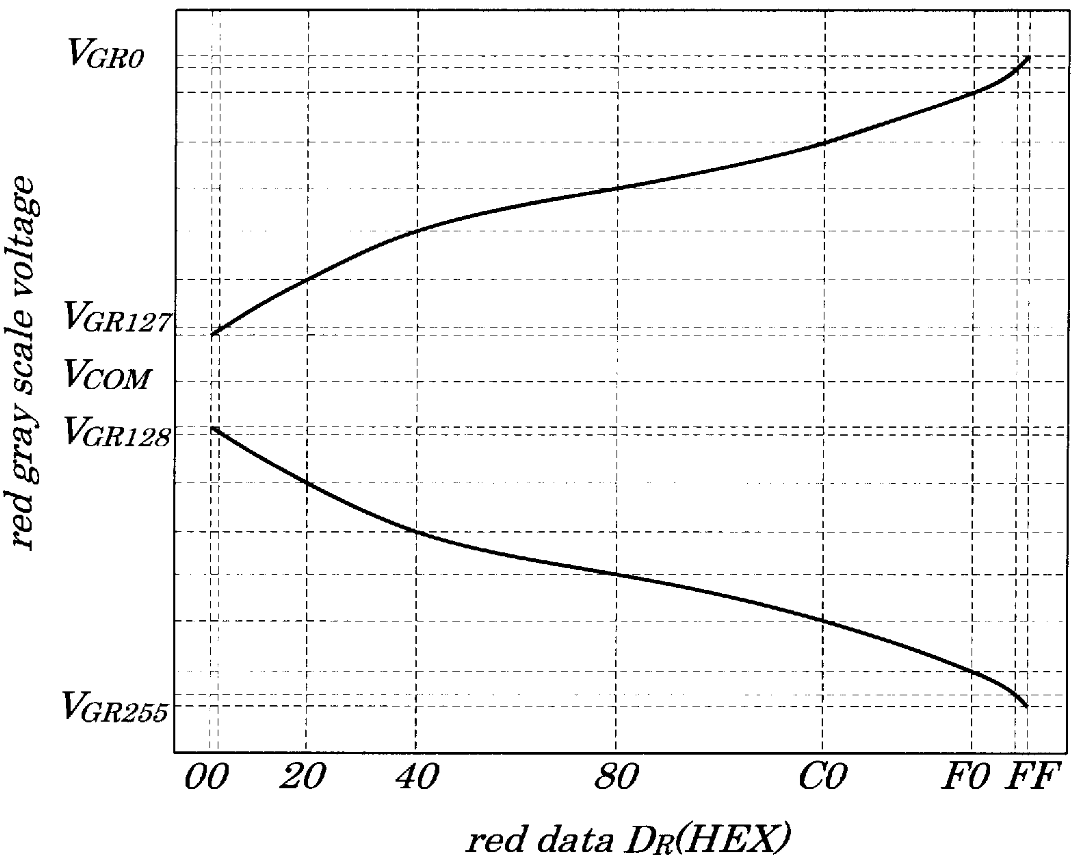

25R;data signal output section
33R
MPX
8
DR
POL
S7S4S1
S382
32R;gray scale voltage splitting section
341
342
34254
34255
VR0
VR1
VR2
VR15
VR16
VR17

FIG.6

FIG. 7



V_{GR0}
V_{GR127}
V_{COM}
V_{GR128}
V_{GR255}
red gray scale voltage
00
20
40
80
C0
F0
FF
red data D_R(HEX)

FIG.8

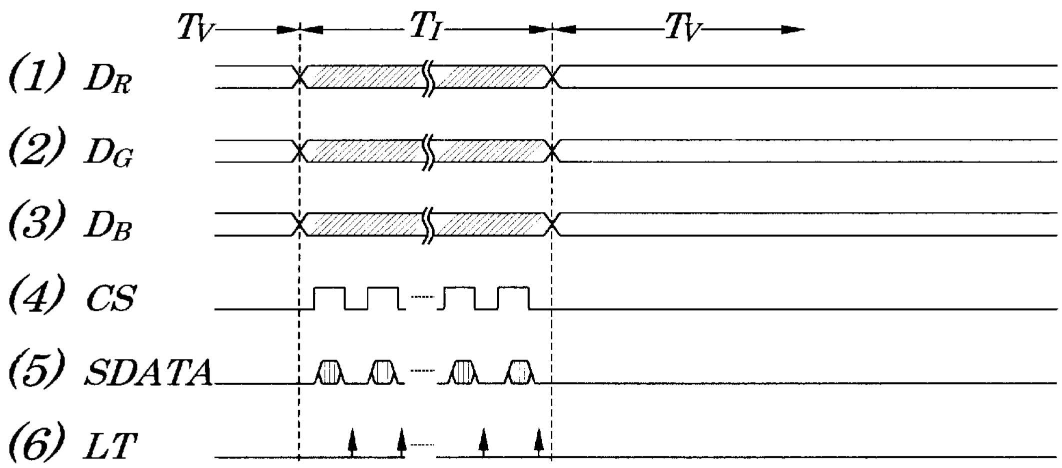

TV
TI
TV
(1) DR
(2) DG
(3) DB
(4) CS
(5) SDATA
(6) LT

FIG.9

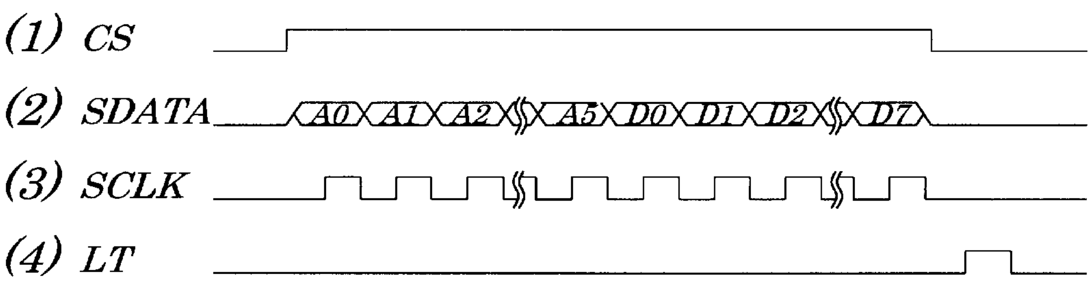
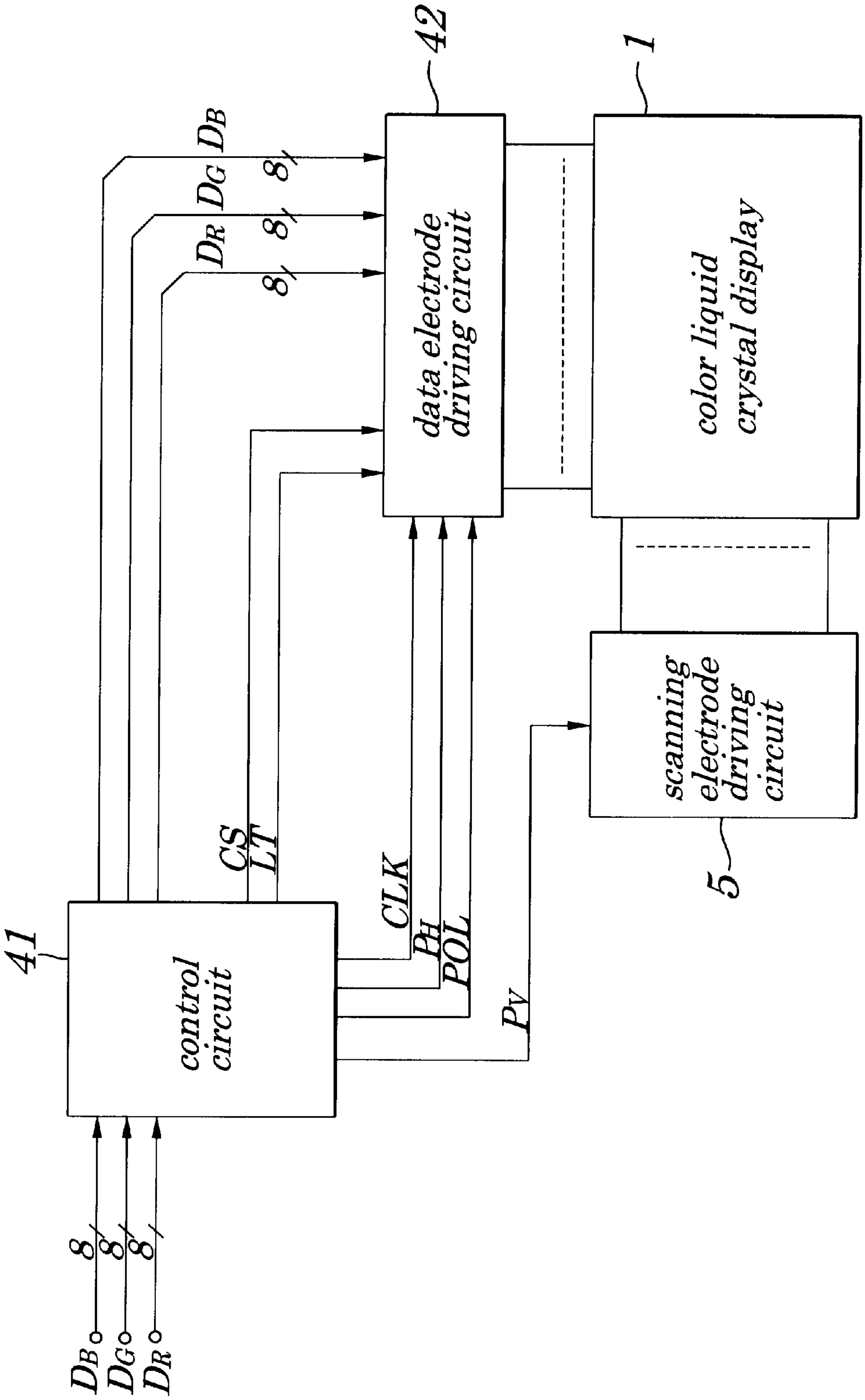

(1) CS
(2) SDATA
A0
A1
A2
A5
D0
D1
D2
D7
(3) SCLK
(4) LT

FIG.10



41
control circuit
42
data electrode driving circuit
1
color liquid crystal display
5
scanning electrode driving circuit
DB
DG
DR
8
CS
LT
CLK
PH
POL
PV

FIG. 11A

red gray scale voltage information								gray scale voltage
D_{R7}	D_{R6}	D_{R5}	D_{R4}	D_{R3}	D_{R2}	D_{R1}	D_{R0}	
0	0	0	0	0	0	0	0	V_0
0	0	0	0	0	0	0	1	V_1
0	0	0	0	0	0	1	0	V_2
0	0	0	0	0	0	1	1	V_3
0	0	0	0	0	1	0	0	V_4
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
1	1	1	1	1	1	0	0	V_{252}
1	1	1	1	1	1	0	1	V_{253}
1	1	1	1	1	1	1	0	V_{254}
1	1	1	1	1	1	1	1	V_{255}

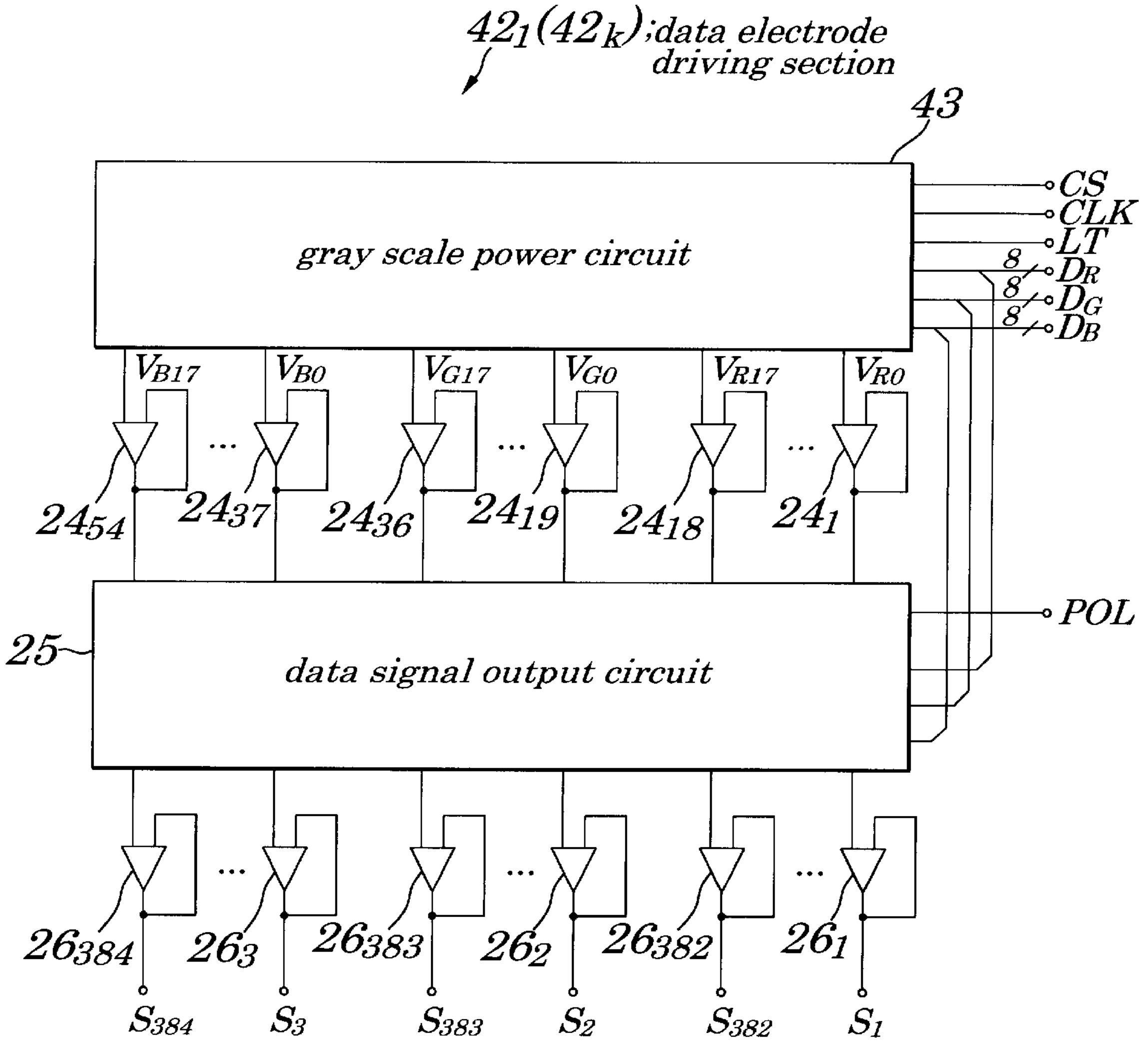
FIG. 11B

green gray scale voltage information								gray scale voltage
D_{G7}	D_{G6}	D_{G5}	D_{G4}	D_{G3}	D_{G2}	D_{G1}	D_{G0}	
0	0	0	0	0	0	0	0	V_0
0	0	0	0	0	0	0	1	V_1
0	0	0	0	0	0	1	0	V_2
0	0	0	0	0	0	1	1	V_3
0	0	0	0	0	1	0	0	V_4
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
1	1	1	1	1	1	0	0	V_{252}
1	1	1	1	1	1	0	1	V_{253}
1	1	1	1	1	1	1	0	V_{254}
1	1	1	1	1	1	1	1	V_{255}

FIG. 11C

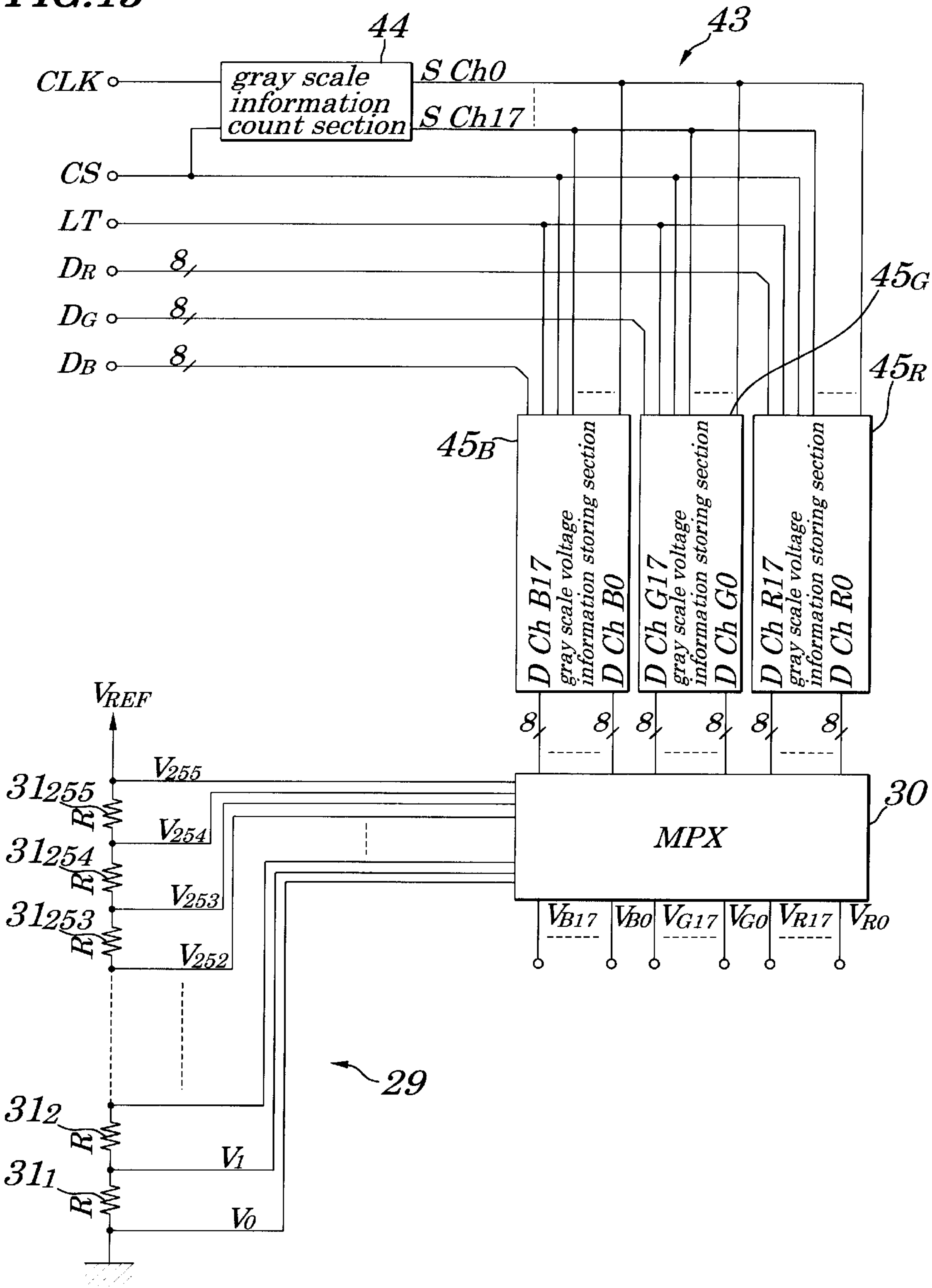
blue gray scale voltage information								gray scale voltage
D_{B7}	D_{B6}	D_{B5}	D_{B4}	D_{B3}	D_{B2}	D_{B1}	D_{B0}	
0	0	0	0	0	0	0	0	V_0
0	0	0	0	0	0	0	1	V_1
0	0	0	0	0	0	1	0	V_2
0	0	0	0	0	0	1	1	V_3
0	0	0	0	0	1	0	0	V_4
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
1	1	1	1	1	1	0	0	V_{252}
1	1	1	1	1	1	0	1	V_{253}
1	1	1	1	1	1	1	0	V_{254}
1	1	1	1	1	1	1	1	V_{255}

FIG. 12



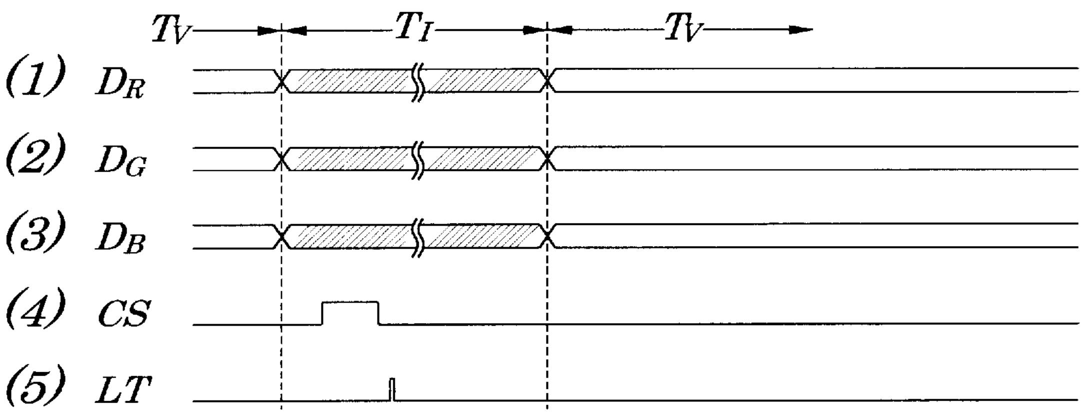
42₁ (42k);data electrode driving section
43
gray scale power circuit
CS
CLK
LT
8
DR
8
DG
8
DB
VB17
VB0
VG17
VG0
VR17
VR0
24_54
24_37
24_36
24_19
24_18
24_1
25
data signal output circuit
POL
26_384
26_3
26_383
26_2
26_382
26_1
S384
S3
S383
S2
S382
S1

FIG. 13



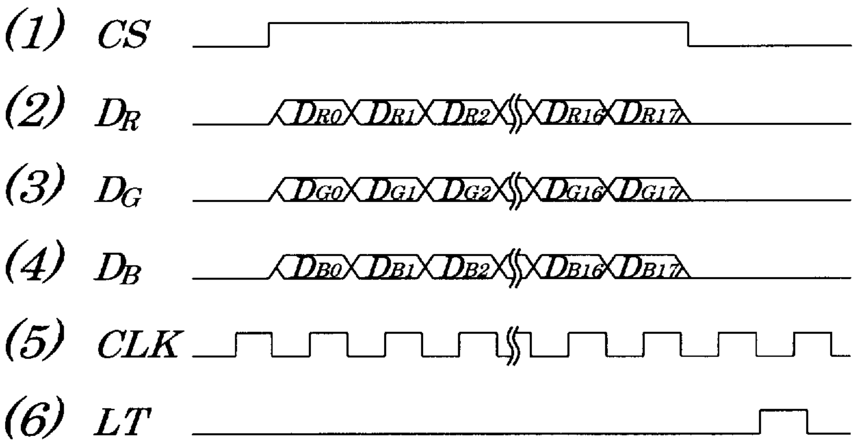
44
43
CLK
gray scale information count section
S Ch0
S Ch17
CS
LT
DR
DG
DB
8
8
8
45G
45R
45B
D Ch B17
gray scale voltage information storing section
D Ch B0
D Ch G17
gray scale voltage information storing section
D Ch G0
D Ch R17
gray scale voltage information storing section
D Ch R0
VREF
V255
V254
V253
V252
31255
31254
31253
312
311
R
V1
V0
MPX
30
VB17
VB0
VG17
VG0
VR17
VR0
29

FIG.14



TV
TI
TV
(1) DR
(2) DG
(3) DB
(4) CS
(5) LT

FIG.15



(1) CS
(2) DR
DR0 DR1 DR2 DR16 DR17
(3) DG
DG0 DG1 DG2 DG16 DG17
(4) DB
DB0 DB1 DB2 DB16 DB17
(5) CLK
(6) LT

FIG. 16

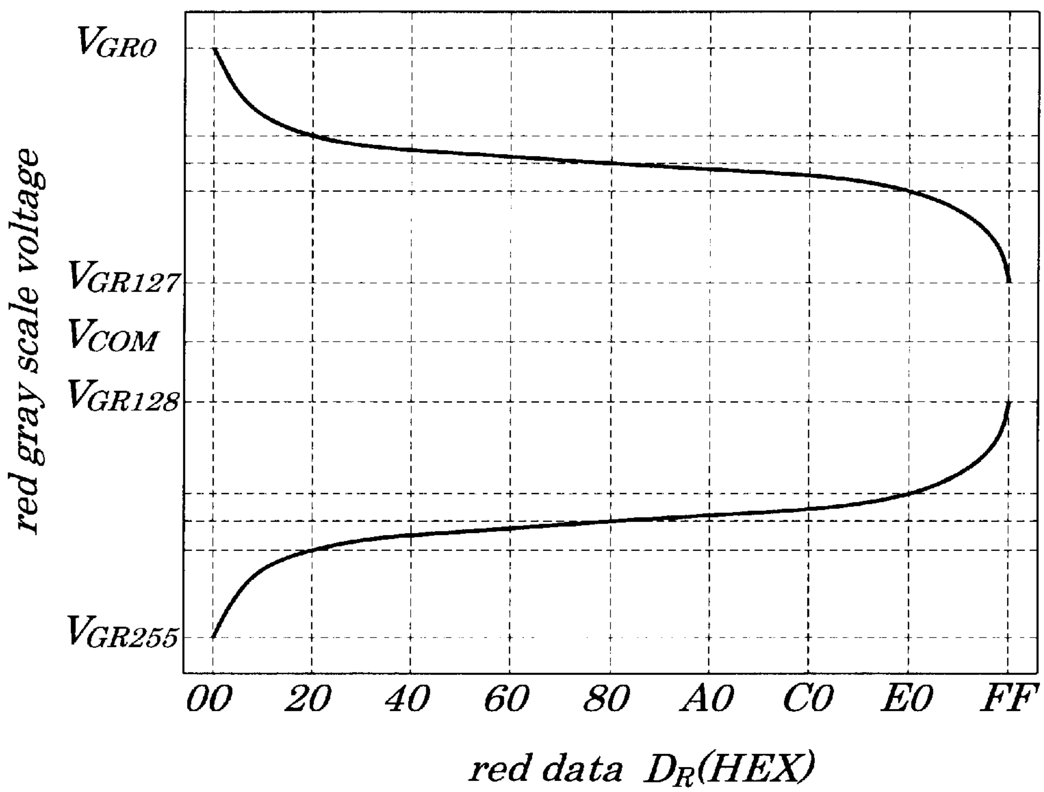

VGR0
VGR127
VCOM
VGR128
VGR255
red gray scale voltage
00
20
40
60
80
A0
C0
E0
FF
red data DR(HEX)

FIG. 17 (PRIOR ART)

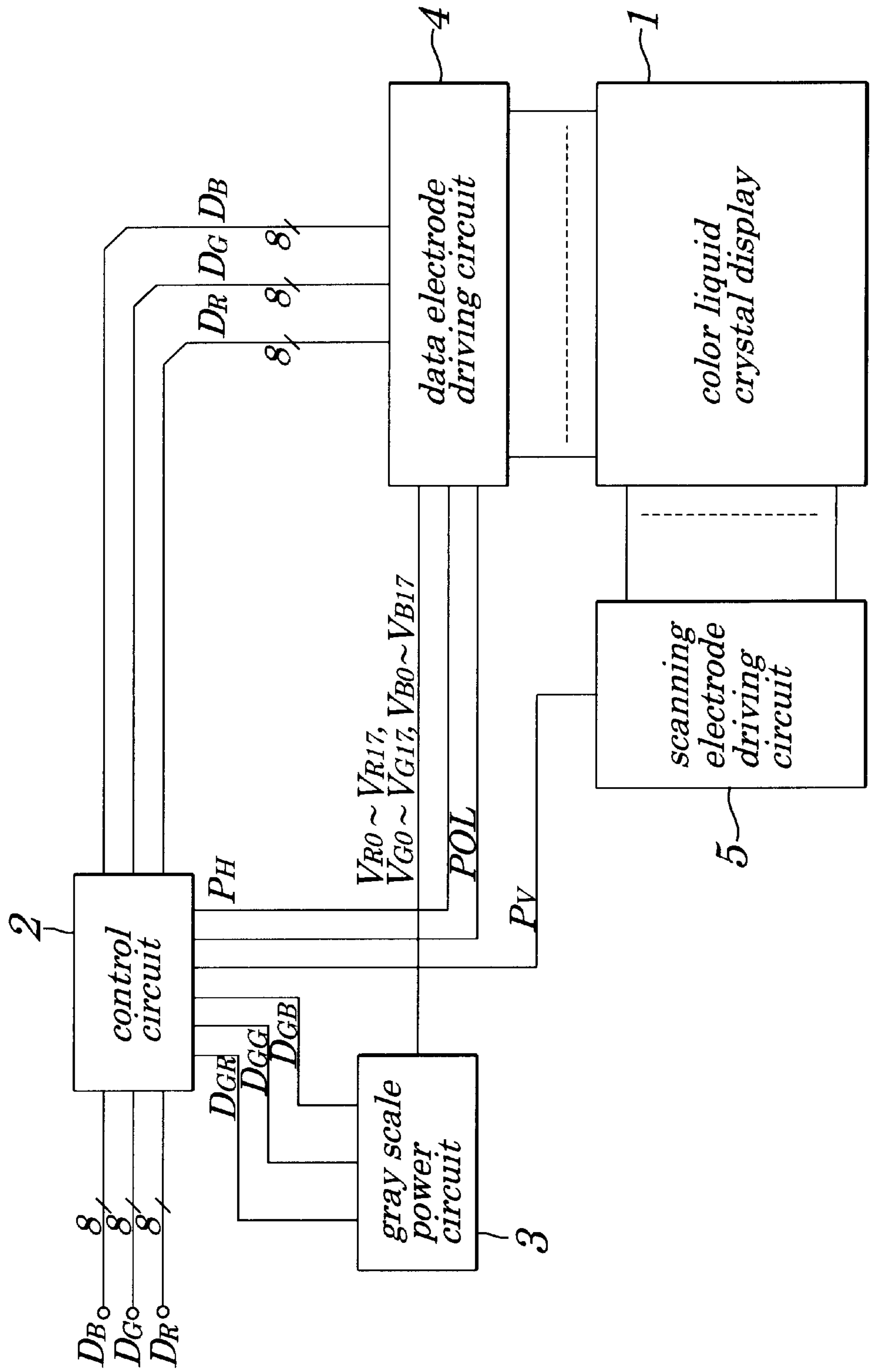


FIG. 18 (PRIOR ART)

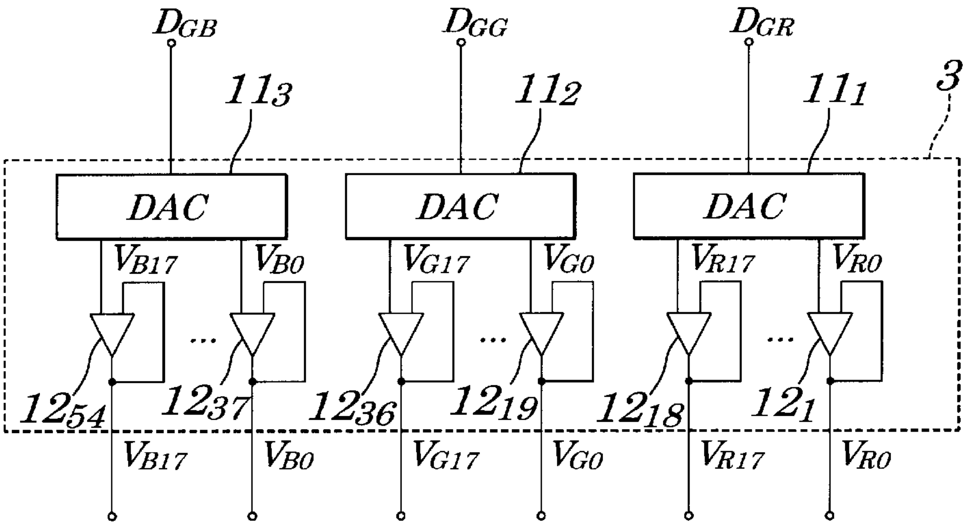


FIG. 19 (PRIOR ART)

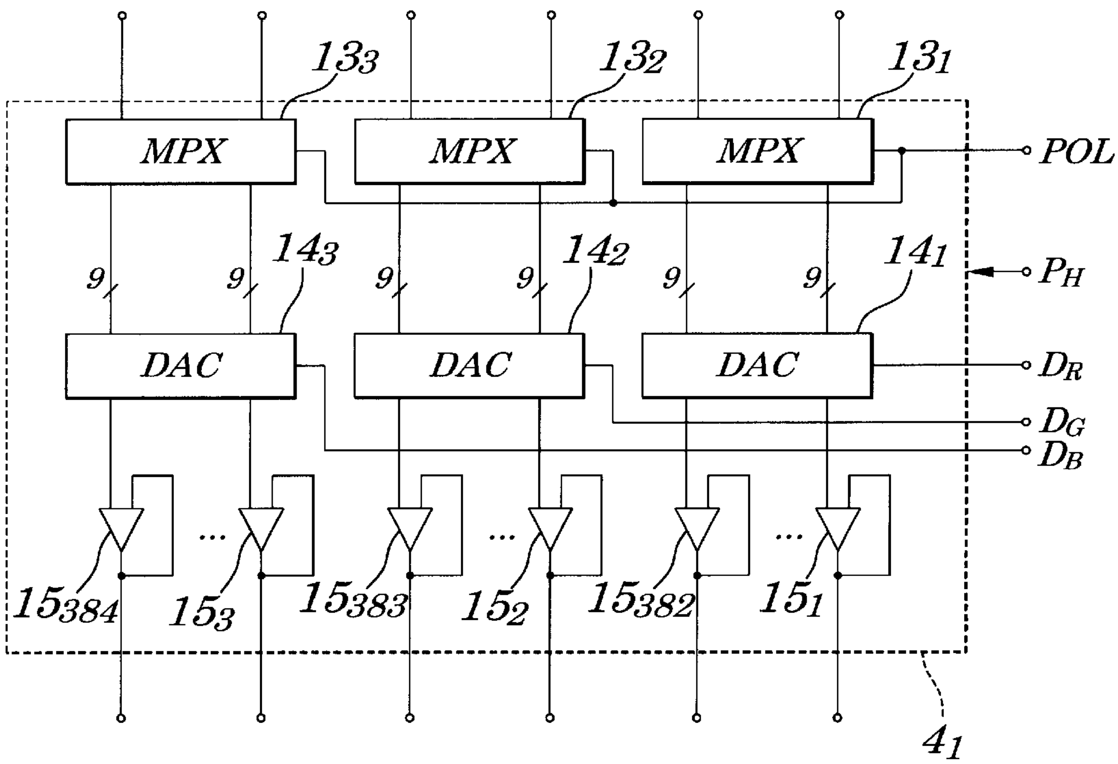


FIG.20 (PRIOR ART)

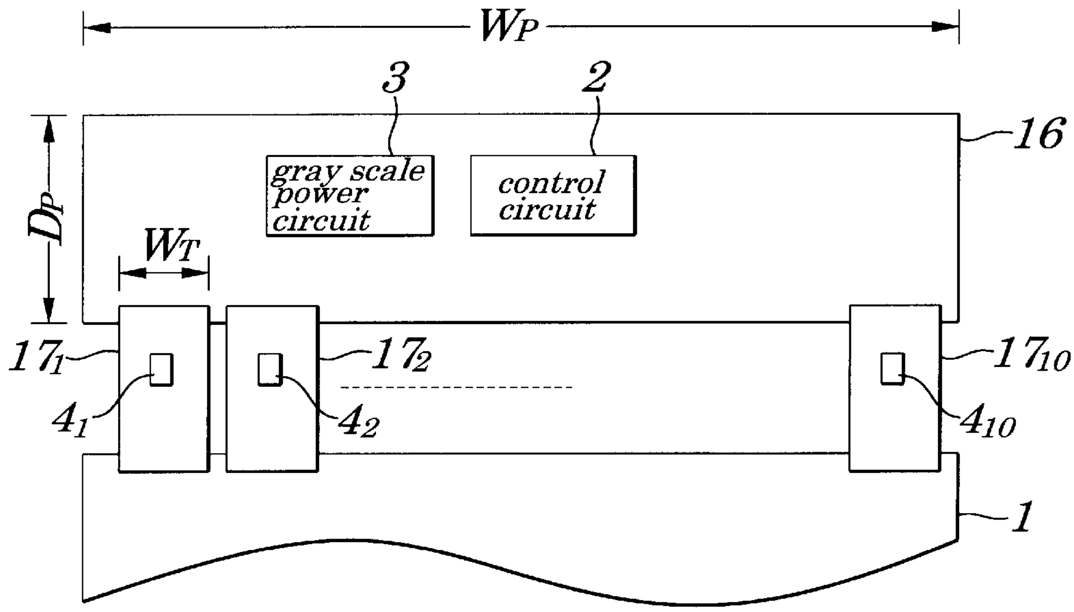
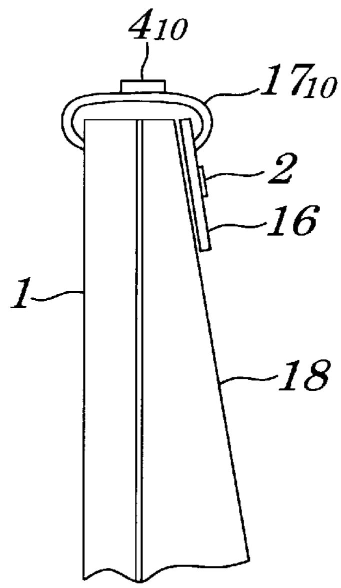


FIG.21 (PRIOR ART)



DRIVING CIRCUIT AND DRIVING METHOD OF COLOR LIQUID CRYSTAL DISPLAY, AND COLOR LIQUID CRYSTAL DISPLAY DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a driving circuit and a driving method of a color liquid crystal display, and a color liquid crystal display device; and more particularly to the driving circuit of the color liquid crystal display adapted to drive the color liquid crystal display based on digital video data to which a gamma correction has been made, the display device having such the driving circuit of the color liquid crystal display, and the method for driving the color liquid crystal display.

The present application claims priority of Japanese Patent Application No.2000-353427 filed on Nov. 20, 2000, which is hereby incorporated by reference.

2. Description of the Related Art

FIG. **17** is a schematic block diagram showing an example of configurations of a conventional driving circuit of a color liquid crystal display **1** disclosed in Japanese Laid-open Patent Application No. 2001-134242 published on May 18, 2001 later than the filing date of Japanese Patent Application No. 2000-353427 corresponding to the present application (Therefore, Japanese Laid-open Patent Application No. 2001-134242 has not a qualification as a prior art reference.)

The disclosed color liquid crystal display **1** is of a type of color liquid crystal display that is driven by an active-matrix driving method and that uses, for example, a TFT (Thin Film Transistor) as a switching element. Pixels are disposed in a region surrounded by a plurality of scanning electrodes (gate lines) mounted at predetermined intervals in a row direction and by a plurality of data electrodes (source lines) mounted at predetermined intervals in a column direction. Each of the pixels has a liquid crystal cell being equivalently a capacitive load, the TFT used to drive a corresponding liquid crystal cell and a capacitor used to accumulate a data charge during one vertical sync period. By applying a data red signal, data green signal, and data blue signal to be produced, based on red data D_R, green data D_G, and blue data D_B being digital video data, to the data electrode and, at the same time, by applying scanning signals to be produced based on a horizontal sync signal and a vertical sync signal to the scanning electrode, a color character, color image or a like is displayed (though not shown in FIG. **17**). Moreover, the disclosed color liquid crystal display **1** operates in a so-called "normally black mode" in which transmittance or luminance of light obtained when an off-driving voltage is applied is lower than those obtained when the on-driving voltage is applied.

As shown in FIG. **17**, the disclosed driving circuit of the color liquid crystal display **1** chiefly includes a control circuit **2**, a gray scale power circuit **3**, a data electrode driving circuit **4**, and a scanning electrode driving circuit **5**.

The control circuit **2** is made up of, for example, ASICs (Application Specific Integrated Circuits) and is adapted to feed 8 bits of red data D_R, 8 bits of green data D_G, and 8 bits of blue data D_B supplied from an outside to the data electrode driving circuit **4** and, at the same time, to produce a horizontal scanning pulse P_H, a vertical scanning pulse P_V, and a polarity reversed pulse POL used to drive the color liquid crystal display **1** with alternating current, based on the horizontal sync signal and vertical sync signal, and to feed these pulses to the data electrode driving circuit **4** and the scanning electrode driving circuit **5**. Moreover, the control circuit **2** feeds a red gray scale voltage data D_{GR}, a green gray scale voltage data D_{GG}, and a blue gray scale voltage data D_{GB} obtained by making an individual and separate gamma correction to each of the red data D_R, green data D_G, and blue data D_B to provide gray scales, to the gray scale power circuit **3**. Moreover, the gamma correction employed in the embodiment includes one gamma correction (hereinafter referred to as a first gamma correction) in which the correction is made to arbitrarily provide a characteristic of luminance required in reproduced images to luminance of input images and another gamma correction (hereinafter referred to as a second gamma correction) that is made to match an "applied voltage–transmittance" characteristic (hereinafter as a V–T characteristic) for each of the red, green, and blue colors used in the color liquid crystal display **1**.

The gray scale power circuit **3**, as shown in FIG. **18**, includes digital/analog converters (DACs) $\mathbf{11}_1$ to $\mathbf{11}_3$ and voltage followers $\mathbf{12}_1$ to $\mathbf{12}_{54}$. The DAC $\mathbf{11}_1$ converts the red gray scale data DGR fed from the control circuit **2** into analog red gray scale voltages V_{R0} to V_{R17} and feeds them to the voltage followers $\mathbf{12}_1$ to $\mathbf{12}_{18}$, respectively. Similarly, the DAC $\mathbf{11}_2$ converts the green gray scale data D_{GG} fed from the control circuit **2** into analog green gray scale voltages V_{G0} to V_{G17} and feeds them to the voltage followers $\mathbf{12}_{19}$ to $\mathbf{12}_{36}$, respectively. The DAC $\mathbf{11}_3$ converts the blue gray scale data D_{GB} fed from the control circuit **2** into analog green gray scale voltages V_{B0} to V_{B17} and feeds them to the voltage followers $\mathbf{12}_{37}$ to $\mathbf{12}_{54}$, respectively. The voltage followers $\mathbf{12}_1$ to $\mathbf{12}_{54}$ feed the red gray scale voltages V_{R0} to V_{R17}, the corresponding green gray scale voltages V_{G0} to V_{G17}, and the blue gray scale voltages V_{B0} to V_{B17}, which are all used for making the gamma correction, as they are, to the data electrode driving circuit **4**.

The data electrode driving circuit **4** is made up of k pieces ("k" being a natural number) of data electrode driving sections $\mathbf{4}_1$ to $\mathbf{4}_k$. Each of the data electrode driving sections $\mathbf{4}_1$ to $\mathbf{4}_k$ makes the gamma correction, based on red gray scale voltages V_{R0} to V_{R17}, green gray scale voltages V_{G0} to V_{G17}, and blue gray scale voltages V_{B0} to V_{B17} fed from the gray scale power circuit **3**, to the red data D_R, green data D_G, and blue data D_B each corresponding to each of data electrodes mounted in the color liquid crystal display **1**, out of the red data D_R, the green data D_G, and the blue data D_B fed from the control circuit **2**, in order to provide gray scales, and converts the gamma-corrected data into 384 pieces of analog data signals and then outputs them. For example, when the color liquid crystal display **1** is of a type of SXGA (Super Extended Graphics Array) which provides 1280×1024 pixel resolution, since one pixel is made up of three dot pixels including a red (R) dot pixel, a green (G) dot pixel, and a blue (B) dot pixel, the number of dot pixels becomes 3840×1024. Therefore, in the example, the data electrode driving circuit **4** is made up of ten pieces of data electrode driving sections $\mathbf{4}_1$ to $\mathbf{4}_{10}$ (3840 pieces of pixels÷384 pieces of data signals). Since all of the data electrode driving sections $\mathbf{4}_1$ to $\mathbf{4}_{10}$ have the same configurations except that each of their components and each of input and output signals have a different subscript, a description of only the data electrode driving section $\mathbf{4}_1$ will be provided below.

FIG. **19** is a schematic block diagram showing an example of configurations of the data electrode driving section $\mathbf{4}_1$. As shown in FIG. **19**, the data electrode driving section $\mathbf{4}_1$ chiefly includes multiplexers (MPXs) $\mathbf{13}_1$ to $\mathbf{13}_3$, DACs $\mathbf{14}_1$

to 14_3 (of an 8 bit-data conversion type), and voltage followers 15_1 to 15_{384}. The MPX 13_1 switches a set of red gray scale voltages V_{R0} to V_{R8} or a set of red gray scale voltages V_{R9} to V_{R17}, out of red gray scale voltages V_{R0} to V_{R17} fed from the gray scale power circuit **3**, based on a polarity reversed pulse POL fed from the control circuit **2** and feeds the switched voltages to the DAC 14_1. Similarly, the MPX 13_2 switches a set of red gray scale voltages V_{G0} to V_{G8} or a set of green gray scale voltages V_{G9} to V_{G17}, out of green gray scale voltages V_{G0} to V_{G17} fed from the gray scale power circuit **3**, based on the polarity reversed pulse POL fed from the control circuit **2** and feeds the switched voltages to the DAC 14_2. The MPX 13_2 switches a set of red gray scale voltages V_{B0} to V_{B8} or a set of green gray scale voltages V_{B9} to V_{B17}, out of green gray scales V_{B0} to V_{B17} fed from the gray scale power circuit **3**, based on the polarity reversed pulse POL fed from the control circuit **2** and feeds the switched voltages to the DAC 14_3.

The DAC 14_1 makes the gamma correction, based on the set of red gray scale voltages V_{R0} to V_{R8} or the set of the red gray scale voltages V_{R9} to V_{R17} fed from the MPX 13_1, to 8 bits of the red data D_R fed from the control circuit **2** in order to provide gray scales and, after having converted the gamma-corrected data to analog data red signals, feeds them to the corresponding voltage followers 15_1, 15_4, 15_7, . . . , 15_{382}. Similarly, the DAC 14_2 makes the gamma correction, based on the set of green gray scale voltages V_{G0} to V_{G8} or the set of the green gray scale voltages V_{G9} to V_{G17} fed from the MPX 13_2, to 8 bits of the green data D_G fed from the control circuit **2** in order to provide gray scales and, after having converted the gamma-corrected data to analog data red signals, feeds them to the corresponding voltage followers 15_2, 15_5, 15_8, . . . , 15_{383}. The DAC 14_3 makes the gamma correction, based on the set of blue gray scale voltages V_{B0} to V_{B8} or the set of the blue gray scale voltages V_{B9} to V_{B17} fed from the MPX 13_3, to 8 bits of the blue data D_B fed from the control circuit **2** in order to provide gray scales and, after having converted the gamma-corrected data to analog data red signals, feeds them to the corresponding voltage followers 15_3, 15_6, 15_9, . . . , 15_{384}. The voltage followers 15_1 to 15_{384} apply the corresponding data red signal, data green signal, and data blue signal fed from the DAC 14_1 to 14_3 to the corresponding data electrode in the color liquid crystal display **1**.

The scanning electrode driving circuit **5** shown in FIG. **17** produces scanning signals with the timing when the vertical scanning pulse PV is fed from the control circuit **2** and sequentially feeds the produced signals to corresponding scanning electrodes in the color liquid crystal display **1**.

In the display device of the color liquid crystal display **1** provided with the driving circuit of the color liquid crystal display **1** having configurations described above, as shown in FIG. **20**, the control circuit **2** and the gray scale power circuit **3** are mounted on a printed circuit board **16** while the data electrode driving sections 4_1 to 4_{10} are mounted on ten pieces of film carrier tapes electrically connecting the printed circuit board **16** to the color liquid crystal display **1**, that is, they are packaged in a form of TCPs (Tape Carrier Packages) 17_1 to 17_{10}. As shown in FIG. **21**, the printed circuit board **16** is attached to an upper portion of a rear of a backlight **18** being approximately wedge-shaped in cross section which is attached to a rear of the color liquid crystal display **1**. The backlight **18** has a point light source such as a white bulb or a like or a line light source such as a fluorescent lamp or a like, and a light diffusing member used to diffuse light emitted from these light sources to produce flat light and is adapted to uniformly illuminate the rear of the color liquid crystal display **1** from a rear side of the color liquid crystal display **1** being a non-light emitting display device.

The conventional color liquid crystal display **1** has a problem. That is, as described above, in the driving circuit of the conventional color liquid crystal display **1**, since the gray scale power circuit **3** and the data electrode driving sections 4_1 to 4_{10} are mounted individually and separately from each other, it is necessary to feed 54 pieces of gray scale voltages including the red gray scale voltages V_{R0} to V_{R17}, green gray scale voltages V_{G0} to V_{G17}, and blue gray scale voltages V_{B0} to V_{B17} to each of ten pieces of the data electrode driving sections 4_1 to 4_{10}. Two methods for feeding such gray scale voltages are available, however, each of them has a shortcoming as described below.

A first method is to form 54 pieces of wirings on a surface layer of the printed circuit board **16** and to connect each of the wirings to each of the TCPs 17_1 to 17_{10}. A pitch between the wirings being employed generally and presently is 1.27 mm. If, therefore, 54 pieces of wirings are to be formed, using the above pitch, on the surface layer of the printed circuit board **16**, a depth of the printed circuit board **16** becomes longer by 2 cm or more, compared with a case where 54 pieces of gray scale voltages including the red gray scale voltages V_{R0} to V_{R17}, green gray scale voltages V_{G0} to V_{G17}, and blue gray scale voltages V_{B0} to V_{B17} are transferred serially using one wiring (refer to FIG. **20**). This causes, as shown in FIG. **21**, an area in which the printed circuit board **16** is mounted on the upper portion of the rear of the backlight **18** to become wider. Generally, the backlight **18** plays not only a part in illuminating uniformly the rear of the color liquid crystal display **1** but also a part in keeping a rear portion of the display device plane and can be used commonly for any color liquid crystal display **1** so long as it has the same screen in size. However, if the depth of the printed circuit board **16** is different in every type of the color liquid crystal display **1**, that is, in every resolution that the color liquid crystal display **1** can provide, it is necessary to change a shape of the backlight **18** for every type of the color liquid crystal display **1**, that is, every resolution to be provided by the color liquid crystal display **1**, which causes an increase in costs of the display device.

The limit pitch between terminals of the typical TCP being presently employed is 300 μm when considerations are given to a level of pressure-based contact technology by which each of terminals of the TCP is put in contact with each of terminals of the printed circuit board **16** by using external pressure in order to obtain electrical conductivity. Therefore, if each of terminals being connected to 54 pieces of wirings formed on the surface layer of the printed circuit board **16** is connected to each of terminals formed on upper portions of the TCP 17_1 to 17_{10} by using the pressure-based contact technology, each of widths WT of the TCP 17_1 to 17_{10} becomes larger by 1.6 cm or more (refer to FIG. **20**). As a result, in the case of the 18-inch type color liquid crystal display of the SXGA type in which ten pieces of the data electrode driving sections 4_1 to 4_{10} have to be placed, since the fitting width for the TCP 17_1 to 17_{10} becomes larger by 16 cm or more, there is a danger that it becomes physically impossible to mount ten pieces of the TCP 17_1 to 17_{10} in alignment in a direction of the width W_P of the printed circuit board **16** (see FIG. **20**).

A second method is to form 54 pieces of wirings in an inner layer of the printed circuit board **16** and to connect each of them to each of the TCP 17_1 to 17_{10}. In this case, in order to connect the 54 pieces of wirings formed in the inner layer of the printed circuit board **16** to each of terminals formed on the upper portions of the TCP 17_1 to 17_{10}, the 54 pieces of wirings formed in the inner layer of the printed circuit board **16** have to be connected to 54 pieces of terminals formed via through holes on the surface layer of the printed circuit board **16** and being corresponded to the 54 pieces of wirings. Since a diameter of a typical through hole being presently employed is 0.8 mm, if the 54 pieces of such the through holes having the diameter of 0.8 mm are to be formed on the printed circuit board **16** in alignment, an area required for forming all the through holes has to become wider accordingly.

In both the first and second methods described above, if the number of gray scale voltages including the red gray scale voltages V_{R0} to V_{R17}, green gray scale voltages V_{G0} to V_{G17}, and blue gray scale voltages V_{B0} to V_{B17} is different, the pitch between wirings, depth D_P of the printed circuit board **16**, width W_T of each of the TCP 17_1 to 17_{10} are different and, therefore, the printed circuit board **16** and the TCP 17_1 to 17_{10} have to be fabricated in a manner so as to meet the requirement in dimensions, which causes a big increase in costs of the display device.

SUMMARY OF THE INVENTION

In view of the above, it is an object of the present invention to provide a driving circuit of a color liquid crystal display which is capable of reducing a substrate packaging area, using a common substrate or TCP even when a resolution and/or the number of gray scale voltages that the color liquid crystal display provides are different, which enables the substrate, TCP, and a display device to be fabricated at low costs. It is also another object of the present invention to provide a color liquid crystal display device using the driving circuit described above and a method for driving the color liquid crystal display.

According to a first aspect of the present invention, there is provided a driving circuit of a color liquid crystal display including:

- a data electrode driving circuit to drive the color liquid crystal display by using a gray scale voltage selected based on a video signal out of a plurality of gray scale voltages; and
- wherein the data electrode driving circuit produces a plurality of the gray scale voltages corresponding to a gray scale voltage characteristic based on digital gray scale voltage setting data to be supplied.

According to a second aspect of the present invention, there is provided a driving circuit of a color liquid crystal display for driving the color liquid crystal display by using a data red signal, a data green signal, and a data blue signal obtained by making an individual gamma correction to red data, green data, and blue data being digital video data in order to make corrections so that each of the red data, the green data, and the blue data matches a transmittance characteristic of each of a red color, a green color, and a blue color for a voltage applied in the color liquid crystal display, the driving circuit including:

- a control circuit mounted separately from the color liquid crystal display and to output, during an invalid period having no bearing on a displaying period for the digital video data, information about the gamma correction to be made to the red data, the green data, and the blue data; and
- a data electrode driving circuit mounted in a vicinity of the color liquid crystal display and to drive the color liquid crystal display by using the data red signal, the data green signal, and the data blue signal obtained by making the gamma correction to the red data, the green data, and the blue data, based on information about the gamma correction to be made to the red data, the green data, and the blue data.

In the foregoing, a preferable mode is one wherein the control circuit is mounted on a printed circuit board attached to an upper portion of a rear of a backlight placed on a rear of the color liquid crystal display and wherein the data electrode driving circuit includes a plurality of data electrode driving sections to provide gray scales by making the gamma correction to the red data, the green data, and the blue data each corresponding to each of data electrodes of the color liquid crystal display, out of the red data, the green data, and the blue data and converts the gamma-corrected red data, the gamma-corrected green data, and the gamma-corrected blue data into an analog data red signal, an analog data green signal, and an analog data blue signal, such that the analog data red signal, the analog data green signal, and the analog data blue signal are output, and wherein each of the plurality of the data electrode driving sections is mounted on a corresponding film carrier tape connecting the printed circuit board to the color liquid crystal display.

Also, a preferable mode is one wherein the information about the gamma correction to be made to the red data, the green data, and the blue data, is made up of gray scale information to provide an instruction as to which gray scale voltage should be selected out of the gray scale voltages for the red data, the green data, and the blue data, and of gray scale voltage information to provide an instruction as to which gray scale voltage should be selected out of the plurality of the gray scale voltages.

Also, a preferable mode is one wherein the control circuit feeds the gray scale information and the gray scale voltage information to the data electrode driving circuit as serial data.

Also, a preferable mode is one wherein each of the data electrode driving sections includes:

- a shift register to convert the serial data into parallel gray scale information and parallel gray scale voltage information, such that the parallel gray scale information and the parallel gray scale voltage information;
- a storing section to store, in advance, a selection signal to provide an instruction as to which gray scale voltage should be selected as a plurality of gray scale voltages for the red data, the green data, and the blue data;
- a decoder to decode the gray scale information and to output selection information to provide an instruction as to which gray scale voltage should be selected out of the plurality of the gray scale voltages for the red data, the green data, the and blue data;
- a multiplexer to select any one of the gray scale voltgage based on the selection signal read from the storing section according to the selection information and to output the selected gray scale voltage as a plurality of red gray scale voltages, green gray scale voltages, and blue gray scale voltages; and
- a data signal output section to provide gray scales by making the gamma correction to the red data, the green data, and the blue data, based on the plurality of the red gray scale voltages, the green gray scale voltages, and the blue gray scale voltages and to convert the gamma-corrected red data, the gamma-corrected green data, and the gamma-corrected blue data into an analog data red signal, an analog data green signal, and an analog data blue signal.

Also, a preferable mode is one wherein the control circuit feeds the gray scale voltage information by using wirings prepared to supply the red data, the green data, and the blue data to the data electrode driving circuit.

Also, a preferable mode is one wherein a number of counts of clocks used to capture the red data, the green data, and the blue data in the data electrode driving circuit, is associated, in a one-to-one relationship, with an order in which the gray scale voltage information about the red data, the green data, and the blue data is fed to the data electrode driving circuit and wherein the number of counts of clocks is used as the gray scale information.

Also, a preferable mode is one wherein each of the data electrode driving sections includes:

a red gray scale voltage information storing section to store, in advance, a selection signal to provide an instruction as to which gray scale voltage should be selected as a plurality of the red gray scale voltages for the red data;

a green gray scale voltage information storing section to store, in advance, a selection signal to provide an instruction as to which gray scale voltage should be selected as a plurality of the green gray scale voltages for the green data;

a blue gray scale voltage information storing section to store, in advance, a selection signal to provide an instruction as to which gray scale voltage should be selected as a plurality of the blue gray scale voltages for the blue data;

a gray scale information count section to count a number of supplied clocks and to output selection information to provide an instruction as to which gray scale voltage should be selected out of a plurality of the gray scale voltages according to the number of counts of the clocks;

a multiplexer to select any one of gray scale voltages based on the selection signal read from the red gray scale information storing section, the green gray scale information storing section, and the blue gray scale information storing section according to the selection information and to output the selected gray scale voltage as a plurality of red gray scale voltages, a plurality of green gray scale voltages, and a plurality of blue gray scale voltages; and

a data signal output section to provide gray scales by making the gamma correction to the red data, the green data, and the blue data based on the plurality of the red gray scale voltages, the green gray scale voltages, and the blue gray scale voltages and to convert the gamma-corrected red data, the gamma-corrected green data, and the gamma-corrected blue data into an analog data red signal, an analog data green signal, and an analog data blue signal, such that the analog data red signal, the analog data green signal, and the analog data blue signal are output.

Also, a preferable mode is one wherein the gamma correction includes the gamma correction which is made in order to arbitrarily provide a characteristic of luminance required in reproduced images to luminance of input images.

According to a third aspect of the present invention, there is provided a display device having a driving circuit of a color liquid crystal display including:

a data electrode driving circuit to drive the color liquid crystal display by using a gray scale voltage selected based on a video signal out of a plurality of gray scale voltages; and

wherein the data electrode driving circuit produces a plurality of the gray scale voltages corresponding to a gray scale voltage characteristic based on digital gray scale voltage setting data to be supplied.

According to a fourth aspect of the present invention, there is provided a display device having a driving circuit of a color liquid crystal display for driving the color liquid crystal display by using a data red signal, a data green signal, and a data blue signal obtained by making an individual gamma correction to red data, green data, and blue data being digital video data in order to make corrections so that each of the red data, the green data, and the blue data matches a transmittance characteristic of each of a red color, a green color, and a blue color for a voltage applied in the color liquid crystal display, the driving circuit including:

a control circuit mounted separately from the color liquid crystal display and to output, during an invalid period having no bearing on a displaying period for the digital video data, information about the gamma correction to be made to the red data, the green data, and the blue data; and

a data electrode driving circuit mounted in a vicinity of the color liquid crystal display and to drive the color liquid crystal display by using the data red signal, the data green signal, and the data blue signal obtained by making the gamma correction to the red data, the green data, and the blue data, based on information about the gamma correction to be made to the red data, the green data, and the blue data.

According to a fifth aspect of the present invention, there is provided a method for driving a color liquid crystal display by using a data red signal, a data green signal, and a data blue signal obtained by making an individual gamma correction to red data, green data, and blue data being digital video data in order to make corrections so that each of the red data, the green data and the blue data matches a transmittance characteristic of each of red, green, and blue colors for a voltage applied in the color liquid crystal display, the method including:

a step of feeding, from a control circuit mounted separately from the color liquid crystal display, during an invalid period having no bearing on a displaying period for the digital video data, information about the gamma correction to be made to the red data, the green data, and the blue data, to a data electrode driving circuit mounted in a vicinity of the color liquid crystal display and to drive the color liquid crystal display by using the data red signal, the data green signal, and the data blue signal obtained by making the gamma correction to the red data, the green data, and the blue data, based on information about the gamma correction to be made to the red data, the green data, and the blue data.

With the above configurations, the driving circuit of the color liquid crystal display incorporates the data electrode driving circuit adapted to drive the color liquid crystal display using the gray scale voltage selected based on the video signals out of a plurality of gray scale voltages and the data electrode driving circuit is so configured that a plurality of the gray scale voltages being able to correspond to gray scale voltage characteristics is produced based on digital gray scale voltage setting data and, therefore, the substrate packaging area can be reduced and even if the resolution of the color liquid crystal display and/or the number of the gray scale voltages are different, the common substrate and/or TCP can be used, which enables the substrate and/or TCP, that is, the display device to be manufactured at low costs.

With another configuration as above, during the invalid period having no bearing on the displaying period of the digital video data, information about the gamma correction to be made to the red data, the green data, and the blue data is transmitted serially from the control circuit mounted separately from the color liquid crystal display to the data electrode driving circuit adapted to drive the color liquid crystal display and, therefore, the number of wirings required to connect the control circuit to the data electrode driving circuit can be reduced.

With still another configuration as above, the information about the gamma correction to be made to the red data, the green data, and the blue data, during the invalid period, is supplied by using wirings prepared to feed the red data, the green data, and the blue data to the data electrode driving circuit and, therefore, effective use of the wirings is made possible.

With still another configuration as above, the red gray scale voltage, the green gray scale voltage, and the blue gray scale voltage can be set in one operation and, therefore, the processing is made simple and the time required for the setting can be shortened.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, advantages, and features of the present invention will be more apparent from the following description taken in conjunction with the accompanying drawings in which:

FIG. **1** is a block diagram showing configurations of a driving circuit of a color liquid crystal display according to a first embodiment of the present invention;

FIG. **2** shows one example of relations between each of bits **A5** to **A0** of gray scale information and each of channels Ch **R0** to Ch **R17**, Ch **G0** to Ch **G17**, and Ch **B0** to Ch **B17** employed in the first embodiment of the present invention;

FIG. **3** shows one example of relations between each of bits **D7** to **D0** of gray scale voltage information and each of gray scale voltages V_0 to V_{255} employed in the first embodiment of the present invention;

FIG. **4** is a schematic block diagram showing configurations of a data electrode driving section $\mathbf{22}_1$ being part of a data electrode driving circuit **22** making up the driving circuit of the color liquid crystal display according to the first embodiment of the present invention;

FIG. **5** is a schematic block diagram showing configurations of a gray scale power circuit **23** making up the data electrode driving section $\mathbf{22}_1$ of FIG. **4**;

FIG. **6** is a schematic block diagram showing configurations of a data signal output section $\mathbf{25}_R$ being part of a data signal output circuit **25** making up the data electrode driving section $\mathbf{22}_1$ of FIG. **4**;

FIG. **7** is a diagram showing one example of a relation between 8 bits of red data D_R to be fed to the data signal output section $\mathbf{25}_R$ and red gray scale voltages V_{GR0} to V_{GR127} and V_{GR128} to V_{GR255} employed in the driving circuit of the color liquid crystal display according to the first embodiment of the present invention;

FIG. **8** is a timing chart explaining one example of operations of the driving circuit of the color liquid crystal display according to the first embodiment of the present invention;

FIG. **9** is also a timing chart explaining another example of operations of the driving circuit of the color liquid crystal display according to the first embodiment of the present invention;

FIG. **10** is a block diagram showing configurations of a driving circuit of a color liquid crystal display according to a second embodiment of the present invention;

FIGS. **11A**, **11B**, and **11C** show examples of relations between each of bits **DR7** to **DR0**, **DG7** to **DG0**, **DB7** to **DB0** of red gray scale voltage information D_{R0} to D_{R17}, green gray scale voltage information D_{G0} to D_{G17} and blue gray scale voltage information D_{B0} to D_{B17} and each of gray scale voltages V_0 to V_{255} employed in the second embodiment of the present invention;

FIG. **12** is a schematic block diagram showing configurations of a data electrode driving section $\mathbf{42}_1$ being part of a data electrode driving circuit **42** making up the driving circuit of the color liquid crystal display according to the second embodiment of the present invention;

FIG. **13** is a schematic block diagram showing configurations of a gray scale power circuit **43** making up the data electrode driving section $\mathbf{42}_1$ according to the second embodiment of the present invention;

FIG. **14** is a timing chart explaining one example of operations of the driving circuit according to the second embodiment of the present invention;

FIG. **15** is also a timing chart explaining one example of operations of the driving circuit according to the second embodiment of the present invention;

FIG. **16** is a diagram showing one example of a relation between 8 bits of red data D_R to be fed to a data signal output section $\mathbf{25}_R$ being part of a data electrode driving circuit **22** making up a driving circuit of a color liquid crystal display being a modified example of the present invention and red gray scale voltages V_{GR0} to V_{GR127} and V_{GR128} to V_{GR255};

FIG. **17** is a schematic block diagram showing an example of configurations of a conventional driving circuit in a color liquid crystal display;

FIG. **18** is a schematic block diagram showing an example of configurations of a gray scale power circuit **3** making up the conventional driving circuit of FIG. **17**;

FIG. **19** is a schematic block diagram showing an example of configurations of a data electrode driving section $\mathbf{4}_1$ making up a data electrode driving circuit **4** contained in the conventional driving circuit of FIG. **17**;

FIG. **20** is a schematic block diagram illustrating a packaging state in the conventional driving circuit of FIG. **17**; and

FIG. **21** is a schematic block diagram illustrating another packaging state in the conventional driving circuit of FIG. **17**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Best modes of carrying out the present invention will be described in further detail using various embodiments with reference to the accompanying drawings.

First Embodiment

FIG. **1** is a block diagram showing configurations of a driving circuit of a color liquid crystal display **1** according to a first embodiment of the present invention. In FIG. **1**, same reference numbers are assigned to corresponding parts in FIG. **17** and their descriptions are omitted accordingly. In the color liquid crystal display **1** shown in FIG. **1**, instead of a control circuit **2**, a gray scale power circuit **3**, and a data electrode driving circuit **4** shown in FIG. **17**, a control circuit **21**, and a data electrode driving circuit **22** are newly provided.

The control circuit **21** is made up of, for example, ASICs (Application Specific Integrated Circuits) and feeds 8 bits of red data D_R, 8 bits of green data D_G, and 8 bits of blue data D_B which are all supplied from the outside, to the data electrode driving circuit **22** and, at the same time, produces a horizontal scanning pulse P_H, a vertical scanning pulse P_V, a polarity reversed pulse POL, a clock CLK, a chip selection signal CS, a shift clock SCLK, a latch signal LT, and a serial data SDATA, based on a horizontal sync signal and a vertical sync signal fed from the outside and then supplies them to both the data electrode driving circuit **22** and a scanning electrode driving circuit **5**.

The clock CLK is used to capture the red data D_R, the green data D_G, and the blue data D_B in data registers making up the data electrode driving circuit **22**. The chip selection signal CS is a signal which goes "high" for a predetermined time during a period having no bearing on an image displaying period such as a vertical retrace interval, horizontal retrace interval, or a like (hereinafter referred to as an "invalid period"). The shift clock SCLK being asynchronous to the clock CLK is used to capture the serial data SDATA in the data electrode driving circuit **22**. The latch signal LT is a signal used to provide timing with which, as shown in FIG. **5**, a gray scale voltage information storing section **28** captures parallel information to be fed from a shift register **27** in "k" ("k" is a natural number) pieces of data electrode driving sections $\mathbf{22}_1$ to $\mathbf{22}_K$ (see FIG. **4**)

The serial data SDATA is made up of (n+1) ("n" being a natural number) bits of parallel gray scale information and (m+1) ("m" being a natural number) bits of gray scale voltage information and is fed to the data electrode driving circuit **22**, while the chip selection signal CS remains "high", in synchronization with the shift clock SCLK. The parallel gray scale information is used to provide an instruction as to which channel out of channels Ch R**0** to Ch R**17**, Ch G**0** to Ch G**17**, and Ch B**0** to Ch B**17** should be set to give the gray scale voltage to each of the red data D_R, the green data D_G, and the blue data D_B, in order to provide gray scales by making individual and separate gamma correction to each of the red data D_R, the green data D_G, and the blue data D_B. FIG. **2** shows one example of relations between each of bits of the parallel gray scale information **A5** to **A0** and each of the channels Ch R**0** to Ch R**17**, Ch G**0** to Ch G**17**, and Ch B**0** to Ch B**17** given when "n"=5.

The gray scale voltage information is used to provide an instruction as to which voltage out of 256 pieces of the gray scale voltages V_0 (=V_{REF}/255×0=0[V]) to V_{255} (=V_{REF}/255×255=V_{REF}[V]) to be fed from a gray scale voltage supplying source **29** (see FIG. **5**) to a multiplexer (MPX) **30** is to be selected in each of the data electrode driving sections $\mathbf{22}_1$ to $\mathbf{22}_K$ making up the data electrode driving circuit **22** (FIG. **1**), in order to provide gray scales by making the individual and separate gamma correction to each of the red data D_R, the green data D_G and the blue data D_B. A V_{REF} denotes a reference voltage (FIG. **5**). FIG. **3** shows one example of relations between each of bits of the gray scale voltage information D**7** to D**0** and each of parallel gray scale voltages V_0 to V_{255} given when "m"=7. The gamma correction used in the first embodiment includes both the first and second gamma corrections described above.

The data electrode driving circuit **22** shown in FIG. **1** includes "k" pieces of the data electrode driving sections $\mathbf{22}_1$ to $\mathbf{22}_k$ (FIG. **4**). Each of the data electrode driving sections $\mathbf{22}_1$ to $\mathbf{22}_k$ makes the gamma correction to the red data D_R, green data D_G, and blue data D_B corresponding to the data electrode in the color liquid crystal display **1**, out of the red data D_R, the green data D_G, and the blue data D_B fed from the control circuit **21**, to provide gray scales, and converts the gamma-corrected data to 384 pieces of analog data signals S_1 to S_{384} and then outputs the converted data (see FIG. **4**). For example, if the color liquid crystal display **1** is of the SXGA (Super Extended Graphics Array) type, the data electrode driving circuit **22** includes ten pieces of the data electrode driving sections $\mathbf{22}_1$ to $\mathbf{22}_{10}$. Since all of the data electrode driving sections $\mathbf{22}_1$ to $\mathbf{22}_{10}$ have the same configurations except that each of their components and each of input and output signals have a different subscript, a description of only the data electrode driving section $\mathbf{22}_1$ will be provided below.

As shown in FIG. **4**, the data electrode driving section $\mathbf{22}_1$ chiefly includes a gray scale power circuit **23**, voltage followers $\mathbf{24}_1$ to $\mathbf{24}_{54}$, a data signal output circuit **25** and voltage followers $\mathbf{26}_1$ to $\mathbf{26}_{384}$. Moreover, though the data electrode driving section $\mathbf{22}_1$ actually has a shift register, data register, latch, level shifter or a like on a front stage (not shown) of the data signal output circuit **25**, since their components and operations have no direct bearing on a characteristic portion of the present invention, descriptions of them are omitted in this specification. Therefore, in FIG. **4**, a circuit providing the horizontal scanning pulse P_H is not shown.

As shown in FIG. **5**, the gray scale power circuit **23** includes a shift register **27**, a gray scale voltage information storing section **28**, a gray scale voltage supplying source **29**, and an MPX **30**. The shift register **27**, while the chip selection signal CS remains "high", captures the serial data SDATA in synchronization with the shift clock SCLK and outputs 8 bits of parallel gray scale information **A5** to **A0** and 8 bits of the parallel gray scale voltage information D**7** to D**0**.

The gray scale voltage information storing section **28** is made up of a semiconductor memory such as a ROM, RAM, flash memory EEPROM (Electrically erasable PROM) or a like and mainly includes a storing section (not shown) in which each of 8 bits of selection signals D Ch R**0** to D Ch R**17**, D Ch G**0** to D Ch G**17**, and D Ch B**0** to D Ch B**17** is stored in each of the channels Ch R**0** to Ch R**17**, Ch G**0** to Ch G**17**, and Ch B**0** to Ch B**17**, respectively, and a decoder (not shown) used to decode 6 bits of the parallel gray scale information **A5** to **A0** fed from the shift register **27** and to output selection information SChR**0** to SChR**17**, SChG**0** to SChG**17**, and SChB**0** to SChB**17** (not shown) each of which provides an instruction as to which channel is to be selected out of the channels Ch R**0** to Ch R**17**, Ch G**0** to Ch G**17**, and Ch B**0** to Ch B**17**. The gray scale voltage information storing section **28**, with timing when the latch signal LT fed from the control circuit **21** goes "high", captures 6 bits of the parallel gray scale information **A5** to **A0** fed from the shift register **27** and 8 bits of the parallel gray scale voltage information D**7** to D**0** in an inside of the gray scale voltage information storing section **28** and outputs any one of 8 bits of the selection signals D Ch R**0** to D Ch R**17**, D Ch G**0** to D Ch G**17**, and D Ch B**0** to D Ch B**17** selected based on the parallel gray scale voltage information D**7** to D**0** from the channel selected based on the selection information SChR**0** to SChR**17**, SChG**0** to SChG**17**, and SChB**0** to SChB**17** (not shown) obtained by decoding the gray scale information **A5** to **A0** and then feeds them to the MPX **30**.

The gray scale voltage supplying source **29** is provided with 255 pieces of resistors $\mathbf{31}_1$ to $\mathbf{31}_{255}$ each having the same resistance value and being connected serially between a terminal of the reference voltage V_{REF} and a terminal of a ground and feeds 256 pieces of the gray scale voltages V_0(=V_{REF}/255×0=0[V]) to V_{255} (=V_{REF}/255×255=V_{REF} [V]) to the MPX **30**. The MPX **30** selects any one of the 256 pieces of the gray scale voltages V_0 to V_{255} fed from the gray scale voltage supplying source **29** based on the 8 bits of the selection signals D Ch R**0** to D Ch R**17**, D Ch G**0** to D Ch G**17**, and D Ch B**0** to D Ch B**17** fed from the gray scale voltage information storing section **28** and outputs it as one of analog red gray scale voltages V_{R0} to V_{R17}, or one of analog green gray scale voltages V_{G0} to V_{17}, or one of analog blue gray scale voltages V_{B0} to V_{B17}.

The voltage followers $\mathbf{24}_1$ to $\mathbf{24}_{54}$ shown in FIG. **4** feed the analog red gray scale voltages V_{R0} to V_{R17}, analog green gray scale voltages V_{G0} to V_{G17}, and analog blue gray scale voltages V_{B0} to V_{B17} which are all required for making the gamma correction, as they are, to the data signal output circuit **25**. The data signal output circuit **25** splits each of the analog red gray scale voltages V_{R0} to V_{R17}, analog green gray scale voltages V_{G0} to V_{G17}, and analog blue gray scale voltages V_{B0} to V_{B17} into 256 pieces of the red gray scale voltages V_{GR0} to V_{GR255}, 256 pieces of the green gray scale voltages V_{GG0} to V_{GG255}, and 256 pieces of the blue gray scale voltages V_{GB0} to V_{GB255}, respectively and, based on a set of the red gray scale voltages V_{GR0} to V_{GR127} or a set of the red gray scale voltages V_{GR128} to V_{GR255}, a set of the green gray scale voltages V_{GG0} to V_{GG127} or a set of the green gray scale voltages V_{GG128} to V_{GG255}, a set of the blue gray scale voltages V_{GB0} to V_{GB127} or a set of the blue gray scale voltages V_{GB128} to V_{GB255} switched according to the polarity reversed pulse POL fed from the control circuit **21**, makes the gamma correction to the 8 bits of the red data D_R, 8 bits of the green data D_R, and the 8 bits of the blue data D_R to provide gray scales and, at the same time, converts the gamma-corrected data to analog data red signals $S_1, S_4, \ldots, S_7, S_{382}$, analog data green signals $S_2, S_5, \ldots, S_8, S_{383}$, and analog data blue signals $S_3, S_6, \ldots, S_9, S_{384}$, and then feeds the converted data to each of the voltage followers $\mathbf{26}_1$ to $\mathbf{26}_{384}$. The voltage followers $\mathbf{26}_1$ to $\mathbf{26}_{384}$ feed the data red signals $S_1, S_4, \ldots, S_7, S_{382}$, data green signals $S_2, S_5, \ldots, S_8, S_{383}$, and data blue signals $S_3, S_6, \ldots, S_9, S_{384}$, as they are, to each of the corresponding data electrodes in the color liquid crystal display **1**.

The data signal output circuit **25** shown in FIG. **4** is made up of three data signal output sections $\mathbf{25}_R$, $\mathbf{25}_G$, and $\mathbf{25}_B$ corresponding to each of the red data D_R, green data D_G, and blue data D_B. Since all of the data signal output sections $\mathbf{25}_R$, $\mathbf{25}_G$, and $\mathbf{25}_B$ have the same configurations except that each of their components and each of input and output signals have a different subscript, a description of only the data signal output section $\mathbf{25}_R$ (FIG. **6**) will be provided below.

The data signal output section $\mathbf{25}_R$, as shown in FIG. **6**, is made up of a gray scale voltage splitting section $\mathbf{32}_R$ and an MPX $\mathbf{33}_R$. The gray scale voltage splitting section $\mathbf{32}_R$ is provided with 255 pieces of resistors $\mathbf{34}_1$ to $\mathbf{34}_{255}$ each having a different resistance value and being connected serially, and splits the red gray scale voltages V_{R0} to V_{R17} fed from the voltage followers $\mathbf{24}_1$ to $\mathbf{24}_{18}$ into 256 pieces of the red gray scale voltages V_{GR0} to V_{GR255} and feeds them to the MPX $\mathbf{33}_R$. The MPX $\mathbf{33}_R$ makes the gamma correction to the 8 bits of the red data D_R fed from the control circuit **21** to provide gray scales, based on a set of the red gray scale voltages V_{GR0} to V_{GR127} or a set of the red gray scale voltages V_{GR128} to V_{GR255} switched by the polarity reversed pulse POL fed from the control circuit **21** out of 256 pieces of the red gray scale voltages V_{GR0} to V_{GR255} fed from the gray scale voltage splitting section $\mathbf{32}_R$ and, at the same time, converts the gamma-corrected data to the analog data red signals $S_1, S_4, S_7, \ldots, S_{382}$, and then feeds the converted signals to the voltage followers $\mathbf{26}_1$, $\mathbf{26}_4$, $\mathbf{26}_7$, . . . , $\mathbf{26}_{382}$.

FIG. **7** is a diagram showing one example of relations between 8 bits of the red data DR (expressed in hexadecimal) to be fed to the data signal output section $\mathbf{25}_R$ and red gray scale voltages V_{GR0} to V_{GR127} and V_{GR128} to V_{GR255}. As is apparent from FIG. **7**, in the data signal output section $\mathbf{25}_R$, in order to provide gray scales by making the gamma correction including the first and second gamma corrections to the red data D_R, a set of the red gray scale voltages V_{GR0} to V_{GR127} and a set of the red gray scale voltages V_{GR128} to V_{GR255} having voltages being non-linear to the data value of the red data D_R are supplied from the gray scale voltage splitting section $\mathbf{32}_R$ to the MPX $\mathbf{33}_R$.

In the display device provided with the driving circuit of the color liquid crystal display **1** having configurations of the present invention described above, if the configurations are explained by analogy with configuration shown in FIGS. **20** and **21**, only the control circuit **21** (compared to the control circuit **2**) is mounted on the printed circuit board **16** while the data electrode driving sections $\mathbf{22}_1$ to $\mathbf{22}_{10}$ are mounted on ten pieces of film carrier tapes electrically connecting the printed circuit board **16** to the color liquid crystal display **1**, that is, they are packaged in the form of TCPs (Tape Carrier Packages) $\mathbf{17}_1$ to $\mathbf{17}_{10}$ and the printed circuit board **16** is attached to an upper of a rear of a backlight **18** being wedge-shaped in cross section which has been mounted on a rear of the color liquid crystal display **1**.

Next, operations of the control circuit **21** and data electrode driving circuit **22** being characteristic portions of the present invention, out of operations of the driving circuit of the color liquid crystal display **1** having configurations described above, will be explained by referring to the timing charts shown in FIGS. **8** and **9**.

The control circuit **21**, during an invalid period T_I being a period having no bearing on the image displaying period such as an vertical retrace interval or horizontal retrace interval or a like, for example, after power has been applied to the display device provided with the driving circuit of the color liquid crystal display **1** of the embodiment, feeds a chip selection signal CS, a serial data SDATA, a shift clock SCLK, and a latch signal LT to the data electrode driving circuit **22**, with timing shown by **(4)** to **(6)** in FIG. **8**, more particularly, with timing shown by **(1)** to **(4)** in FIG. **9**. That is, the control circuit **21**, during the invalid period T_I, makes the chip selection signal CS shown by **(1)** in FIG. **9** go "high" for a predetermined period and feeds the serial data SDATA made up of 6 bits of the gray scale information **A5** to **A0** (see FIG. **2**) used to provide an instruction as to which channel out of channels Ch R**0** to Ch R**17**, Ch G**0** to Ch G**17**, and Ch B**0** to Ch B**17** should be set to give the gray scale voltage to each of the red data D_R, green data D_G, and blue data D_B as shown in **(2)** in FIG. **9** and 8 bits of the gray scale voltage information **D7** to **D0** (see FIG. **3**) used to provide an instruction as to which gray scale voltage out of 256 pieces of the gray scale voltages V_0 to V_{255}, in synchronization with the shift clock SCLK shown by **(3)** in FIG. **9**, to the data electrode driving circuit **22** and then feeds the latch signal LT shown by **(4)** in FIG. **9** to the data electrode driving circuit **22**.

By above operations, in each of the data electrode driving sections $\mathbf{22}_1$ to $\mathbf{22}_{10}$ making up the data electrode driving circuit **22**, the shift register **27** making up the gray scale power circuit **23**, while the chip selection signal CS is "high", captures the serial data SDATA in synchronization with the shift clock SCLK and outputs 6 bits of parallel gray scale information **A5** to **A0** and 8 bits of parallel gray scale voltage information **D7** to **D0** and feeds them to the gray scale voltage information storing section **28**. Then, the gray scale voltage information storing section **28** captures 6 bits of the parallel gray scale information **A5** to **A0** and 8 bits of the parallel gray scale voltage information D7 to D0 fed from the shift register **27** with timing when the latch signal LT fed from the control circuit **21** goes "high" (see (4) in FIG. **9**) and outputs any one of 8 bits of the selection signals D Ch R**0** to D Ch R**17**, D Ch G**0** to D Ch G**17**, and D Ch B**0** to D Ch B**17** selected based on the parallel gray scale voltage information D7 to D**0** and then feeds it to the MPX **30** from the channel selected based on the selection signals S Ch R**0** to S Ch R**17**, S Ch G**0** to S Ch G**17**, and S Ch B**0** to S Ch B**17** obtained by decoding the parallel gray scale information A**5** to A**0** using the decoder (not shown).

Next, the MPX **30** selects any one of the 256 pieces of the gray scale voltages V_0 to V_{255} fed from the gray scale voltage supplying source **29** based on the 8 bits of selection signals D Ch R**0** to D Ch R**17**, D Ch G**0** to D Ch G**17**, and D Ch B**0** to D Ch B**17** fed from the gray scale voltage information storing section **28** and outputs them as analog red gray scale voltages V_{R0} to V_{R17}, analog green gray scale voltages V_{G0} to V_{G17}, and analog blue gray scale voltages V_{B0} to V_{B17} and, therefore, the voltage followers $\mathbf{24}_1$ to $\mathbf{24}_{54}$ shown in FIG. **4** feed corresponding red gray scale voltages V_{R0} to V_{R17}, green gray scale voltages V_{G0} to V_{G17}, and blue gray scale voltages V_{B0} to V_{B17}, as they are, to the data signal output circuit **25**.

By above operations, in each of the data signal output sections $\mathbf{25}_R$, $\mathbf{25}_G$, and $\mathbf{25}_B$, each of the gray scale voltage splitting sections $\mathbf{32}_R$, $\mathbf{32}_G$ and $\mathbf{32}_B$ splits the red gray scale voltages V_{R0} to V_{R17}, green gray scale voltages V_{G0} to V_{G17} and blue gray scale voltages V_{B0} to V_{B17} fed from the voltage followers $\mathbf{24}_1$ to $\mathbf{24}_{54}$ into 256 pieces of red gray scale voltages V_{GR0} to V_{GR255}, 256 pieces of green gray scale voltages V_{GG0} to V_{GG255} and 256 pieces of blue gray scale voltages V_{GB0} to V_{GB255} and feeds them to the MPX $\mathbf{33}_R$, MPX_G, and MPX $\mathbf{33}_B$.

By the above-described operations repeated sequentially during the invalid period T_I shown in FIG. **8**, the red gray scale voltages V_{GR0} to V_{GR255}, green gray scale voltages V_{GG0} to V_{GG255}, and blue gray scale voltages V_{GB0} to V_{GB255} to which considerations have been given in order to make the most of luminance in the minimum to the maximum range of V–T characteristics corresponding to the red, green, and blue colors for the color liquid crystal display **1**, are set to the MPX $\mathbf{33}_R$, MPX $\mathbf{33}_G$ and MPX $\mathbf{33}_B$.

In such the state described above, the control circuit **21**, as shown in (**1**) to (**3**) in FIG. **8**, during the valid period T_V being a period having a bearing on image displaying period of a color image signal, feeds 8 bits of the red data D_R, green data D_G, and blue data D_B fed from the outside to the data electrode driving circuit **22** in synchronization with the clock CLK to the data electrode driving circuit **22**.

By the above operations, each of the data electrode driving sections $\mathbf{22}_1$ to $\mathbf{22}_{10}$ making up the data electrode driving circuit **22**, based on a set of the red gray scale voltages V_{GR0} to V_{GR127} or a set of the red gray scale voltages V_{GR128} to V_{GR255}, a set of the green gray scale voltages V_{GG0} to V_{GG127} or a set of the green gray scale voltages V_{GG128} to V_{GG255}, and a set of the blue gray scale voltages V_{GB0} to V_{GB127} or a set of the blue gray scale voltages V_{GB128} to V_{GB255} all of which have been switched based on the polarity reversed pulse POL fed from the control circuit **21**, out of the 256 pieces of red gray scale voltages V_{GR0} to V_{GR255}, 256 pieces of green gray scale voltages V_{GG0} to V_{GG255}, and 256 pieces of blue gray scale voltages V_{GB0} to V_{GB255}, makes the gamma correction to 8 bits of the red data D_R, 8 bits of the green data D_G and 8 bits of the blue data D_B fed from the control circuit **21** to provide gray scales and, after having converted the gamma-corrected data to analog data red signals, analog data green signals, and analog data blue signals and causes the voltage followers $\mathbf{26}_1$ to $\mathbf{26}_{384}$ in the data electrode driving circuit $\mathbf{22}_1$ to apply each of these analog signals to each of the corresponding data electrodes in the color liquid crystal display **1**.

Thus, according to the configurations of the embodiment, since the gray scale power circuit **23** is mounted inside the data electrode driving sections $\mathbf{22}_1$ to $\mathbf{22}_{10}$ even when wirings are formed on the surface layer of the printed circuit board **16** by the conventional first method described above, the required number of the wirings is only four each being used to transmit the chip selection signal CS, serial data SDTA, shift clock SCLK, and latch signal LT and, as a result, it is possible to reduce fifty pieces of wirings and to prevent the length of a depth D_P of the printed circuit board **16** (see FIG. **20**) from becoming large and the area (see FIG. **20**) required for the printed circuit board **16** to be mounted on the upper portion of the rear of the backlight **18** (FIG. **21**) from becoming large. Therefore, even if the type of the color liquid crystal display **1**, that is, its resolution is different, the backlight **18** being commonly applicable to any type of the color liquid crystal display **1** can be used and no increase in costs of the display device occurs. Moreover, since a width W_T (see FIG. **20**) of TCP $\mathbf{17}_1$ to $\mathbf{17}_{10}$ does not become larger, it is possible to easily mount ten pieces of the TCP $\mathbf{17}_1$ to $\mathbf{17}_{10}$ in the direction of the width W_T of the TCP $\mathbf{17}_1$ to $\mathbf{17}_{10}$ (see FIG. **20**).

On the other hand, even when the wirings are formed on the inner layer of the printed circuit board **16** by the conventional second method described above, the required number of the wirings is only four. Therefore, even when the four wirings formed on the inner layer of the printed circuit board **16** are to be connected to four wirings connected to corresponding four terminals formed on the surface layer of the printed circuit board **16** through the through hole, it is not necessary to make large the area required for forming all the through holes.

Moreover, according to the configurations of the embodiment, since the gray scale power circuit **23** is mounted inside the data electrode driving sections $\mathbf{22}_1$ to $\mathbf{22}_{10}$, even when the number of the gray scale voltages including the red gray scale voltages V_{R0} to V_{R17}, green gray scale voltages V_{G0} to V_{G17}, and blue gray scale voltages V_{B0} to V_{B17} is different, the area required for forming all the through holes, depth D_P of the printed circuit board **16** and the width W_T of each of the TCP $\mathbf{17}_1$ to $\mathbf{17}_{10}$ remain unchanged and, as a result, even if the type of the color liquid crystal display **1**, that is, its resolution is different, the printed circuit board **16** and the TCP $\mathbf{17}_1$ to $\mathbf{17}_{10}$ being able to be commonly applied to any type of the color liquid crystal display **1** can be used, which can avoid an increase in costs of the printed circuit board **16** and the TCP $\mathbf{17}_1$ to $\mathbf{17}_{10}$ and, therefore, can prevent the costs of the display device from being increased.

Thus, according to the first embodiment, the substrate packaging area can be reduced and even if the resolution of the color liquid crystal display **1** and/or the number of the gray scale voltages are different, the common substrate and/or TCP can be used, which enables the substrate and/or TCP, that is, the display device to be manufactured at low costs.

It is needless to say that, as in the conventional case, it is possible to provide gray scales and to obtain a reproduced image having excellent gray scales by employing the optimum gamma corrections. Moreover, the driving circuit of the present invention can be used in the color liquid crystal display **1** having the high V–T characteristics.

Furthermore, when a collapse of the gray scale in any specified color out of the red, green, and blue colors occurs, the collapse can be recovered by providing changed gray scale information and a changed gray scale voltages, which are to be fed by the control circuit **21** to the data electrode driving circuit **22**, adapted to change the gray scale voltage (any one of the voltages V_{R0} to V_{R17}, V_{G0} to V_{G17}, and V_{B0} to V_{B17}) corresponding to a region of the color in which the collapse of the gray scale has occurred (any one of an area near a white level, area near gray level, and area near black level).

Second Embodiment

FIG. **10** is a block diagram showing configurations of a driving circuit of a color liquid crystal display **1** according to a second embodiment of the present invention. In FIG. **10**, same reference numbers are assigned to corresponding parts in FIG. **1** and their descriptions are omitted accordingly. In the driving circuit of the color liquid crystal display **1** shown in FIG. **10**, instead of a control circuit **21** and a data electrode driving circuit **22** shown in FIG. **1**, a control circuit **41** and a data electrode driving circuit **42** are newly mounted.

The control circuit **41** is made up of, for example, ASICs and feeds 8 bits of red data D_R, 8 bits of green data D_G, and 8 bits of blue data D_B supplied from the outside to the data electrode driving circuit **42**. The control circuit **41** also produce, based on a horizontal sync signal and a vertical sync signal fed from the outside, a horizontal scanning pulse P_H, vertical scanning pulse P_V, polarity reversed pulse POL, clock CLK, chip selection signal CS, and latch signal LT and feeds them to the data electrode driving circuit **42** and a scanning electrode driving circuit **5**.

The clock CLK is used to capture the red data D_R, green data D_G, and blue data D_B in data registers (not shown) making up the data electrode driving circuit **42**. The chip selection signal CS is a signal which goes "high" for a predetermined period during an invalid period having no bearing on an image displaying period such as a vertical retrace interval, horizontal retrace interval, or a like. The latch signal LT is a signal used to provide timing with which, in k ("k" is a natural number) pieces of data electrode driving sections $\mathbf{42}_1$ to $\mathbf{42}_K$ (see FIG. **12**) making up the data electrode driving circuit **42**, each of gray scale voltage information storing sections $\mathbf{45}_R$, $\mathbf{45}_G$, and $\mathbf{45}_B$ (see FIG. **13**) captures red gray scale voltage information D_{R0} to D_{R17} through channels Ch R**0** to CH R**17**, green gray scale voltage information D_{G0} to D_{G17} through channels Ch G**0** to Ch G**17** and blue gray scale voltage information D_{B0} to D_{B17} through channels Ch B**0** to Ch B**17** which are all fed by using wirings prepared to supply 8 bits of parallel red data D_R, 8 bits of parallel green data D_G, and 8 bits of parallel blue data D_B to be fed from the control circuit **41** (refer to FIG. **13**, to be described later in detail).

The red gray scale voltage information D_{R0} to D_{R17}, green gray scale voltage information D_{G0} to D_{G17}, and blue gray scale voltage information D_{B0} to D_{B17} are signals used to provide an instruction as to which gray scale voltage should be selected out of 256 pieces of the gray scale voltages V_0 ($=V_{REF}/255\times0=0$[V]) to V_{255} ($=V_{REF}/255\times255=V_{REF}$[V]) fed from a gray scale voltage supplying source **29** to an MPX **30** (see FIG. **13**) in order to provide gray scales by making an individual and separate gamma correction to each of the red data D_R, green data D_G, and blue data D_B, in each of the data electrode driving sections $\mathbf{42}_1$ to $\mathbf{42}_K$ making up the data electrode driving circuit **42**. A voltage V_{REF} is a reference voltage. FIGS. **11**A, **11**B, and **11**C show one example of relations between each of bits D7 to D**0** of the red gray scale voltage information D_{R0} to D_{R17}, green gray scale voltage information D_{G0} to D_{G17}, and blue gray scale voltage information D_{B0} to D_{B17} and each of the gray scale voltages V_0 to V_{255}. In the embodiment, the counted number of the clocks CLK corresponds to any one of the channel Ch R**0** to CH R**17**, Ch G**0** to Ch G**17**, and Ch B**0** to Ch B**17** each of which also corresponds to the red data D_R, the green data D_G, and the blue data D_B to which the individual and separate gamma correction is made in order to provide gray scales. That is, the counted number of the clocks CLK fed while the chip selection signal CS remains high (see (**1**) in FIG. **15**) corresponds, in a one-to-one relationship, to each of the red gray scale voltage information D_{R0} to D_{R17}, the green gray scale voltage information D_{G0} to D_{G17}, and the blue gray scale voltage information D_{B0} to D_{B17} (see (**2**) to (**4**) in FIG. **15**). For example, each of the red gray scale voltage information D_{R0}, the green gray scale voltage information D_{G0}, and the blue gray scale voltage information D_{B0} fed when the counted number of the clocks CLK is 0 (zero) corresponds to each of the channels Ch R**0**, Ch G**0**, and Ch B**0**. Moreover, the gamma correction employed in the second embodiment also includes the first gamma correction and the second gamma correction described above.

The data electrode driving circuit **42** shown in FIG. **10** is made up of k pieces of the data electrode driving sections $\mathbf{42}_1$ to $\mathbf{42}_K$ (not shown). Each of the data electrode driving sections $\mathbf{42}_1$ to $\mathbf{42}_K$ makes the gamma correction to the red data D_R, green data D_G, and blue data D_B, out of the red data D_R, green data D_G, and blue data D_B fed from the control circuit **41**, each corresponding to each of the data electrodes in the color liquid crystal display **1** in order to provide gray scales and converts the red data D_R, green data D_G, and blue data D_B into 384 pieces of analog data signals S_1 to S_{384} and then outputs them. For example, if the color liquid crystal display **1** is of the SXGA-type, the data electrode driving circuit **42** is made up of 10 pieces of the data electrode driving sections $\mathbf{42}_1$ to $\mathbf{42}_{10}$. Since all of the data electrode driving sections $\mathbf{42}_1$ to $\mathbf{42}_{10}$ have the same configurations except that each of their components and each of input and output signals have a different subscript, a description of only the data electrode driving section $\mathbf{42}_1$ will be provided below.

FIG. **12** is a schematic block diagram showing configurations of a data electrode driving section $\mathbf{42}_1$ according to the second embodiment of the present invention. In FIG. **12**, same reference numbers are assigned to corresponding parts in FIG. **4** and their descriptions are omitted accordingly. In the data electrode driving section $\mathbf{42}_1$, instead of a gray scale power circuit **23** shown in FIG. **4**, a gray scale power circuit **43** is mounted.

FIG. **13** is a schematic block diagram showing configurations of the gray scale power circuit **43**. In FIG. **13**, same reference numbers are assigned to corresponding parts in FIG. **5** and their descriptions are omitted. In FIG. **13**, instead of a shift register **27** and a gray scale voltage information storing section **28** shown in FIG. **5**, a gray scale information count section **44** and gray scale voltage information storing sections $\mathbf{45}_R$, $\mathbf{45}_G$, and $\mathbf{45}_B$ are newly mounted.

The gray scale information count section **44** counts the number of the clocks CLK being fed while the chip selection signal CS is high and then outputs sequentially high-level selection information S Ch**0** to S Ch**17** to provide an instruction as to which channel out of the channels D Ch R**0** to D Ch R**17**, D Ch G**0** to D Ch G**17**, and D Ch B**0** to D Ch

B17 should be selected, based on the resulting number of the clocks CLK. The gray scale voltage information storing sections 45_R, 45_G, 45_B are made up of semiconductor memories such as non-volatile semiconductor memories including ROMs, RAMs, flash EEPROMs, or a like and each of 8 bits of selection signals D Ch **R0** to D Ch **R17**, D Ch **G0** to D Ch G17, and D Ch **B0** to D Ch **B17** is stored in each of its channels Ch **R0** to Ch **R17**, Ch **G0** to Ch **G0** to Ch **G17**, and Ch **B0** to Ch **B17**. The gray scale voltage information storing sections 45_R, 45_G, 45_B capture the red gray scale voltage information D_{R0} to D_{R17}, green gray scale voltage information D_{G0} to D_{G17}, and blue gray scale voltage information D_{B0} to D_{B17}, with timing when the latch signal LT fed from the control circuit **41** goes "high", and output any one of 8 bits of the selection signals D Ch **R0** to D Ch **R17**, D Ch **G0** to D Ch **G17**, and D Ch **B0** to D Ch **B17** selected based on the red gray scale voltage information D_{R0} to D_{R17}, green gray scale voltage information D_{G0} to D_{G17} and blue gray scale voltage information D_{B0} to D_{B17} from the channel selected based on the "high-level" selection information S Ch **0** to S Ch **17** fed from the gray scale information count section **44** and then feed them to the MPX **30**.

In the display device provided with the driving circuit of the color liquid crystal display **1** having configurations of the present invention described above, if the configurations are explained by referring to FIG. **20**, only the control circuit **41** is mounted on the printed circuit board **16** while the data electrode driving sections 42_1 to 42_{10} are mounted on ten pieces of film carrier tapes electrically connecting the printed circuit board **16** to the color liquid crystal display **1**, that is, they are packaged in the form of TCPs (Tape Carrier Packages) 17_1 to 17_{10} and the printed circuit board **16**, as shown in FIG. **21**, is attached to an upper portion of a rear of the backlight **18** (see FIG. **21**) being wedge-shaped in cross section which has been mounted on a rear of the color liquid crystal display **1**.

Next, operations of the control circuit **41** and data electrode driving circuit **42** being characteristic portions of the present invention, out of operations of the driving circuit of the color liquid crystal display **1** having configurations described above will be explained by referring to FIGS. **14** and **15**.

The control circuit **41**, during an invalid period T_I being a period having no bearing on the image displaying period such as an vertical retrace interval or horizontal retrace interval of color video signals or a like after power has been applied to the display device provided with the driving circuit of the color liquid crystal display **1** of the embodiment, feeds the chip selection signal CS, latch signal LT, and clock CLK by using their exclusive wirings and the red gray scale voltage information D_{R0} to D_{R17}, green gray scale voltage information D_{G0} to D_{G17} and blue gray scale voltage information D_{B0} to D_{B17} by using wirings used to feed the red data D_R, green data D_G, and blue data D_B, with timing shown by **(4)** and **(5)** in FIG. **14**, more particularly, with timing shown by **(1)** to **(6)** in FIG. **15**.

That is, the control circuit **41**, during the "invalid" period T_I, makes the chip selection signal CS go "high" for a predetermined period. Also, during the above period, the control circuit **41**, after having fed the 8 bits of the red gray scale voltage information D_{R0} to D_{R17}, 8 bits of the green gray scale voltage information D_{G0} to D_{G17}, and 8 bits of the blue gray scale voltage information D_{B0} to D_{B17} shown by **(2)** to **(4)** in FIG. **15** used to provide an instruction as to which voltage should be selected out of the 256 pieces of the gray scale voltages V_0 to V_{255} (see FIG. **11**), to the data electrode driving circuit **42**, supplies the latch signal LT shown by **(6)** in FIG. **15** in synchronization with the clock CLK shown by **(5)** in FIG. **15**.

In the data electrode driving sections 42_1 to 42_{10} making up the data electrode driving circuit **42**, the gray scale information count section **44** making up the gray scale power circuit **43** counts the number of the clocks CLK fed while the chip selection signal CS remains "high" and sequentially outputs "high-level" selection signals S Ch**0** to S Ch**17**. Then, the gray scale voltage information storing sections 45_R, 45_G, 45_B capture the 8 bits of red gray scale voltage information D_{R0} to D_{R17}, 8 bits of green gray scale voltage information D_{G0} to D_{G17}, and 8 bits of blue gray scale voltage information D_{B0} to D_{B17}, with timing when the latch signal LT fed from the control circuit **41** goes "high" (see **(6)** in FIG. **15**), and output any one of the 8 bits of the selection signals D Ch **R0** to D Ch **R17**, D Ch **G0** to D Ch **G17**, and D Ch **B0** to D Ch **B17** selected based on the red gray scale voltage information D_{R0} to D_{R17}, green gray scale voltage information D_{G0} to D_{G17}, and blue gray scale voltage information D_{BO} to D_{B17} from the channel selected based on the high-level selection information S Ch**0** to S Ch**17** fed from the gray scale information count section **44** and then feeds them to the MPX **30**.

Next, since the MPX **30** selects any one of the **256** pieces of gray scale voltages V_0 to V_{255} fed from the gray scale voltage supplying source **29** based on 8 bits of selection signals D Ch **R0** to D Ch R17, D Ch **G0** to D Ch **G17**, and D Ch **B0** to D Ch **B17** fed from the gray scale voltage information storing section **28** and outputs them as analog red gray scale voltages V_{R0} to V_{R17} analog green gray scale voltages V_{G0} to V_{G17}, and analog blue gray scale voltages V_{B0} to V_{B17}, the voltage followers 24_1 to 24_{54} feeds corresponding red gray scale voltages V_{R0} to V_{R17}, green gray scale voltages V_{G0} to V_{G17}, and blue gray scale voltages V_{B0} to V_{B17}, as they are, to the data signal output circuit **25**.

In each of the data signal output sections 25_R, 25_G, and 25_B making up the data signal output circuit **25**, each of the gray scale voltage splitting sections 32_R, 32_G, and 32_B splits each of the red gray scale voltages V_{R0} to V_{R17}, the green gray scale voltages V_{G0} to V_{G17}, and the green gray scale voltages V_{G0} to V_{G17} fed from the voltage followers 24_1 to 24_{54} into 256 pieces of the red gray scale voltages V_{GR0} to V_{GR255}, the green gray scale voltages V_{GG0} to V_{GG255} the blue gray scale voltages V_{GB0} to V_{GB255} and feeds them to the MPX 33_R, MPX 33_G, and MPX 33_B.

By the above-described operations repeated once, the red gray scale voltages V_{GR0} to V_{GR255}, green gray scale voltages V_{GG0} to V_{GG255}, and blue gray scale voltages V_{GB0} to V_{GB255} to which considerations have been given in order to make the most of luminance in the minimum to the maximum range of V–T (applied voltage–transmittance) characteristics corresponding to the red, green, and blue colors for the color liquid crystal display **1**, are set to the MPX 33_R, MPX 33_G, and MPX 33_B.

Moreover, operations thereafter are the same as those in the first embodiment and therefore their operations are omitted.

Thus, according to the configurations of the embodiment, since the gray scale power circuit **43** is mounted inside the data electrode driving sections 42_1 to 42_{10} when the wirings are formed on the surface layer of the printed circuit board **16** according to the conventional first method described above, the required number of the wirings is only two, each of which is used to transmit the chip selection signal CS and latch signal LT and, as a result, it is possible to reduce 52 pieces of wirings and to prevent the length of the depth D_P of the printed circuit board **16** (see FIG. **20**) from becoming large and the area (see FIG. **20**) required for the printed circuit board **16** to be mounted on the upper portion of the rear of the backlight **18** (see FIG. **21**) from becoming large. Therefore, even if the type of the color liquid crystal display **1**, that is, its resolution is different, the backlight **18** being commonly applicable to any type of the color liquid crystal display **1** can be used and no increase in costs of the display device occurs. Moreover, since the width W_T (see FIG. **20**) of the TCP $\mathbf{17}_1$ to $\mathbf{17}_{10}$ does not become larger, it is possible to easily mount ten pieces of the TCP $\mathbf{17}_1$ to $\mathbf{17}_{10}$ in the direction of the width W_T of the TCP $\mathbf{17}_1$ to $\mathbf{17}_{10}$ (see FIG. **20**).

On the other hand, even when the wirings are formed on the inner layer of the printed circuit board **16** according to the conventional second method described above, the required number of the wirings is only two. Therefore, even when the two wirings formed on the inner layer of the printed circuit board **16** are to be connected to two wirings connected to corresponding two terminals formed on the surface layer of the printed circuit board **16** through the through hole, it is not necessary to make large the area required for forming all through holes.

Moreover, according to the configurations of the embodiment, since the gray scale power circuit **43** is mounted inside the data electrode driving sections $\mathbf{42}_1$ to $\mathbf{42}_{10}$, even when the number of the gray scale voltages including the red gray scale voltages V_{R0} to V_{R17}, green gray scale voltages V_{G0} to V_{G17}, and blue gray scale voltages V_{B0} to V_{B17} is different, the area required for forming all the through holes, depth D_P of the printed circuit board **16** and the width W_T of each of the TCP $\mathbf{17}_1$ to $\mathbf{17}_{10}$ remain unchanged and, as a result, even if the type of the color liquid crystal display **1**, that is, its resolution is different, the printed circuit board **16** and the TCP $\mathbf{17}_1$ to $\mathbf{17}_{10}$ being commonly applicable to any type of the color liquid crystal display **1** can be used, which can avoid the increase in costs of the printed circuit board **16** and the TCP $\mathbf{17}_1$ to $\mathbf{17}_{10}$ and therefore can prevent costs of the display device from being increased.

Thus, according to the second embodiment, the substrate packaging area can be reduced and even if the resolution of the liquid crystal display **1** and/or the number of the gray scale voltages are different, the common substrate and/or TCP can be used, which enables the substrate and/or TCP, that is, the display device to be manufactured at low costs.

Moreover, according to the second embodiment, since the red gray scale voltage information D_{R0} to D_{R17}, green gray scale voltage information D_{G0} to D_{G17}, and blue gray scale voltage information D_{B0} to D_{B17} are fed by using the wirings used to supply the red data D_R, green data D_G, and blue data D_B to the data electrode driving circuit **42**, it is possible to reduce the number of the wirings more compared with the case in the first embodiment and to use the wirings effectively. Furthermore, since the red gray scale voltages V_{GR0} to V_{GR255}, green gray scale voltages V_{GG0} to V_{GG255}, and blue gray scale voltages V_{GB0} to V_{GB255} can be set, in one operation, to the MPX $\mathbf{33}_R$, MPX $\mathbf{33}_G$ and MPX $\mathbf{33}_B$, the processing is made simpler compared with the case in the first embodiment and the time required for the setting can be shortened.

It is needless to say that, as in the conventional case, it is possible to provide gray scales and to obtain an reproduced image having excellent gray scales by employing the optimum gamma corrections. Moreover, the driving circuit of the present invention can be used in the color liquid crystal display **1** having even the high V–T characteristics.

Furthermore, even when the collapse of the gray scale in any specified color out of the red, green, and blue colors occurs, the collapse can be recovered by changed gray scale information and changed gray scale voltages, which are fed by the control circuit **41** to the data electrode driving circuit **42**, adapted to change the gray scale voltages (any one of the voltages V_{R0} to V_{R17}, V_{G0} to V_{G17} and V_{B0} to V_{B17}) corresponding to a region of the color in which the collapse of the gray scale has occurred (any one of an area near a white level, area near gray level, and area near black level).

It is apparent that the present invention is not limited to the above embodiments but may be changed and modified without departing from the scope and spirit of the invention. For example, in the above embodiments, the driving circuit of the present invention is applied to the normally-black type liquid crystal display, however, it may be applied to a normally-white type liquid crystal display in which transmittance or luminance of light obtained when an off-driving voltage is applied is higher than that obtained when the on-driving voltage is applied. In this case, for example, in the above embodiments, the relation between the 8 bits of red data D_R to be fed to the data signal output section $\mathbf{25}_R$ and the red gray scale voltages V_{GR0} to V_{GR127} and V_{GR128} to V_{GR255} is shown not in FIG. **7**, but in FIG. **16**.

Also, in the above embodiments, the present invention is applied to the active-matrix type color liquid crystal display **1** using the TFT as the switching element, however, the present invention may be applied to the color liquid crystal display having any configuration and/or function.

Also, in the above embodiments, the first gamma correction represents the gamma correction which is made in order to arbitrarily provide a characteristic of luminance required in the reproduced image to the luminance of input images and, as an example of the gamma correction, a gamma correction matched with a gamma characteristic (gamma is 2.2) of a CRT display is included, however, a gamma correction that is matched with the gamma characteristic being different from that of the CRT may be used. For example, when various products are sold through a TV broadcast and/or the Internet, in order to achieve excellent matching between colors of actual products and those displayed by the color liquid crystal display, the first gamma correction may be employed.

Also, in the above embodiments, the first and second gamma corrections are used, however, only the second gamma correction may be used.

Also, in the above embodiment, the driving circuit of the present invention is used in the processing of digital video data, however, it may be employed in processing of analog digital video data.

Also, in the gray scale power circuit **23** of the above first embodiment, the decoder is mounted inside the gray scale voltage information storing section **28**, however, the decoder may be mounted outside the gray scale voltage information storing section **28**.

Furthermore, the driving circuit of the color liquid crystal display **1** of the present invention may be used in a display device provided with a color liquid crystal display serving as a monitor for personal computers.

What is claimed is:

1. A driving circuit of a color liquid crystal display comprising:

a data electrode driving circuit to drive said color liquid crystal display by using a gray scale voltage selected based on a video signal out of a plurality of gray scale voltages;

wherein said data electrode driving circuit produces a plurality of said gray scale voltages corresponding to a gray scale voltage characteristic based on digital gray scale voltage setting data to be supplied;

wherein said control circuit is mounted on a printed circuit board attached to an upper portion of a rear of a backlight placed on a rear of said color liquid crystal display and wherein said data electrode driving circuit includes a plurality of data electrode driving sections to provide gray scales by making said gamma correction to said red data, said green data, and said blue data each being corresponding to each of data electrodes of said color liquid crystal display, out of said red data, said green data, and said blue data and converts said gamma-corrected red data, said gamma-corrected green data, and said gamma-corrected blue data into an analog data red signal, an analog data green signal, and an analog data blue signal, such that said analog data red signal, said analog data green signal, and said analog data blue signal are output; and

wherein each of said plurality of said data electrode driving sections is mounted on a corresponding film carrier tape connecting said printed circuit board to said color liquid crystal display.

2. A driving circuit of a color liquid crystal display for driving said color liquid crystal display by using a data red signal, a data green signal, and a data blue signal obtained by making an individual gamma correction to red data, green data, and blue data being digital video data in order to make corrections so that each of said red data, said green data, and said blue data matches a transmittance characteristic of each of a red color, a green color, and a blue color for a voltage applied in said color liquid crystal display, said driving circuit comprising:

a control circuit mounted separately from said color liquid crystal display and to output, during an invalid period having no bearing on a displaying period for said digital video data, information about said gamma correction to be made to said red data, said green data, and said blue data; and

a data electrode driving circuit mounted in a vicinity of said color liquid crystal display and to drive said color liquid crystal display by using said data red signal, said data green signal, and said data blue signal obtained by making said gamma correction to said red data, said green data, and said blue data, based on information about said gamma correction to be made to said red data, said green data, and said blue data;

wherein said control circuit is mounted on a printed circuit board attached to an upper portion of a rear of a backlight placed on a rear of said color liquid crystal display and wherein said data electrode driving circuit includes a plurality of data electrode driving sections to provide gray scales by making said gamma correction to said red data, said green data, and said blue data each being corresponding to each of data electrodes of said color liquid crystal display, out of said red data, said green data, and said blue data and converts said gamma-corrected red data, said gamma-corrected green data, and said gamma-corrected blue data into an analog data red signal, an analog data green signal, and an analog data blue signal, such that said analog data red signal said analog data green signal, and said analog data blue signal are output; and

wherein each of said plurality of said data electrode driving sections is mounted on a corresponding film carrier tape connecting said printed circuit board to said color liquid crystal display.

3. The driving circuit of the color liquid crystal display according to claim **2**, wherein said information about said gamma correction to be made to said red data, said green data, and said blue data, is made up of gray scale information to provide an instruction as to which gray scale voltage should be selected out of said gray scale voltages for said red data, said green data, and said blue data, and of gray scale voltage information to provide an instruction as to which gray scale voltage should be selected out of said plurality of said gray scale voltages.

4. The driving circuit of the color liquid crystal display according to claim **3**, wherein said control circuit feeds said gray scale information and said gray scale voltage information to said data electrode driving circuit as serial data.

5. The driving circuit of the color liquid crystal display according to claim **3**, wherein said control circuit feeds said gray scale voltage information by using wirings prepared to supply said red data, said green data, and said blue data to said data electrode driving circuit.

6. The driving circuit of the liquid crystal display according to claim **2**, wherein each of said data electrode driving sections includes:

a shift register to convert said serial data into parallel gray scale information and parallel gray scale voltage information, such that said parallel gray scale information and said parallel gray scale voltage information;

a storing section to store, in advance, a selection signal to provide an instruction as to which gray scale voltage should be selected as a plurality of gray scale voltages for said red data, said green data, and said blue data;

a decoder to decode said gray scale information and to output selection information to provide an instruction as to which gray scale voltage should be selected out of said plurality of said gray scale voltages for said red data, said green data, and said blue data;

a multiplexer to select any one of said gray scale voltage based on said selection signal read from said storing section according to said selection information and to output said selected gray scale voltage as a plurality of red gray scale voltages, green gray scale voltages, and blue gray scale voltages; and

a data signal output section to provide gray scales by making said gamma correction to said red data, said green data, and said blue data, based on said plurality of said red gray scale voltages, said green gray scale voltages, and said blue gray scale voltages and to convert said gamma-corrected red data, said gamma-corrected green data, and said gamma-corrected blue data into an analog data red signal, an analog data green signal, and an analog data blue signal.

7. The driving circuit of the color liquid crystal display according to claim **2**, wherein said gamma correction includes said gamma correction which is made in order to arbitrarily provide a characteristic of luminance required in reproduced images to luminance of input images.

8. A driving circuit of a color liquid crystal display for driving said color liquid crystal display by using a data red signal, a data green signal, and a data blue signal obtained by making an individual gamma correction to red data, green data, and blue data being digital video data in order to make corrections so that each of said red data, said green data, and said blue data matches a transmittance characteristic of each of a red color, a green color, and a blue color for a voltage applied in said color liquid crystal display, said driving circuit comprising:

a control circuit mounted separately from said color liquid crystal display and to output, during an invalid period having no bearing on a displaying period for said digital video data, information about said gamma correction to be made to said red data, said green data, and said blue data; and

a data electrode driving circuit mounted in a vicinity of said color liquid crystal display and to drive said color liquid crystal display by using said data red signal, said data green signal, and said data blue signal obtained by making said gamma correction to said red data, said green data, and said blue data, based on information about said gamma correction to be made to said red data, said green data, and said blue data;

wherein said information about said gamma correction to be made to said red data, said green data, and said blue data, is made up of gray scale information to provide an instruction as to which gray scale voltage should be selected out of said gray scale voltages for said red data, said green data, and said blue data, and of gray scale voltage information to provide an instruction as to which gray scale voltage should be selected out of said plurality of said gray scale voltages; and

wherein a number of counts of clocks used to capture said red data, said green data, and said blue data in said data electrode driving circuit, is associated, in a one-to-one relationship, with an order in which said gray scale voltage information about said red data, said green data, and said blue data is fed to said data electrode driving circuit and wherein said number of counts of clocks is used as said gray scale information.

9. The driving circuit of the color liquid crystal display according to claim **8**, wherein each of said data electrode driving sections includes:

a red gray scale voltage information storing section to store, in advance, a selection signal to provide an instruction as to which gray scale voltage should be selected as a plurality of said red gray scale voltages for said red data;

a green gray scale voltage information storing section to store, in advance, a selection signal to provide an instruction as to which gray scale voltage should be selected as a plurality of said green gray scale voltages for said green data;

a blue gray scale voltage information storing section to store, in advance, a selection signal to provide an instruction as to which gray scale voltage should be selected as a plurality of said blue gray scale voltages for said blue data;

a gray scale information count section to count a number of supplied clocks and to output selection information to provide an instruction as to which gray scale voltage should be selected out of a plurality of said gray scale voltages according to said number of counts of said clocks;

a multiplexer to select any one of gray scale voltages based on said selection signal read from said red gray scale information storing section, said green gray scale information storing section, and said blue gray scale information storing section according to said selection information and to output said selected gray scale voltage as a plurality of red gray scale voltages, a plurality of green gray scale voltages, and a plurality of blue gray scale voltages; and

a data signal output section to provide gray scales by making said gamma correction to said red data, said green data, and said blue data based on said plurality of said red gray scale voltages, said green gray scale voltages, and said blue gray scale voltages and to convert said gamma-corrected red data, said gamma-corrected green data, and said gamma-corrected blue data into an analog data red signal, an analog data green signal, and an analog data blue signal, such that said analog data red signal, said analog data green signal, and said analog data blue signal are output.

10. A display device provided with a driving circuit of a color liquid crystal display comprising:

a data electrode driving circuit to drive said color liquid crystal display by using a gray scale voltage selected based on a video signal out of a plurality of gray scale voltages; and

wherein said data electrode driving circuit produces a plurality of said gray scale voltages corresponding to a gray scale voltage characteristic based on digital gray scale voltage setting data to be supplied;

wherein said control circuit is mounted on a printed circuit board attached to an upper portion of a rear of a backlight placed on a rear of said color liquid crystal display and wherein said data electrode driving circuit includes a plurality of data electrode driving sections to provide gray scales by making said gamma correction to said red data, said green data, and said blue data each being corresponding to each of data electrodes of said color liquid crystal display, out of said red data, said green data, and said blue data and converts said gamma-corrected red data, said gamma-corrected green data, and said gamma-corrected blue data into an analog data red signal, an analog data green signal, and an analog data blue signal, such that said analog data red signal, said analog data green signal, and said analog data blue signal are output; and

wherein each of said plurality of said data electrode driving sections is mounted on a corresponding film carrier tape connecting said printed circuit board to said color liquid crystal display.

11. A display device provided with a driving circuit of a color liquid crystal display for driving said color liquid crystal display by using a data red signal, a data green signal, and a data blue signal obtained by making an individual gamma correction to red data, green data, and blue data being digital video data in order to make corrections so that each of said red data, said green data, and said blue data matches a transmittance characteristic of each of a red color, a green color, and a blue color for a voltage applied in said color liquid crystal display, said driving circuit comprising:

a control circuit mounted separately from said color liquid crystal display and to output, during an invalid period having no bearing on a displaying period for said digital video data, information about said gamma correction to be made to said red data, said green data, and said blue data; and

a data electrode driving circuit mounted in a vicinity of said color liquid crystal display and to drive said color liquid crystal display by using said data red signal, said data green signal, and said data blue signal obtained by making said gamma correction to said red data, said green data, and said blue data, based on information about said gamma correction to be made to said red data, said green data, and said blue data;

wherein said control circuit is mounted on a printed circuit board attached to an upper portion of a rear of a backlight placed on a rear of said color liquid crystal display and wherein said data electrode driving circuit includes a plurality of data electrode driving sections to provide gray scales by making said gamma correction to said red data, said green data, and said blue data each being corresponding to each of data electrodes of said color liquid crystal display, out of said red data, said green data, and said blue data and converts said gamma-corrected red data, said gamma-corrected green data, and said gamma-corrected blue data into an analog data red signal, an analog data green signal, and an analog data blue signal, such that said analog data red signal, said analog data green signal, and said analog data blue signal are output; and

wherein each of said plurality of said data electrode driving sections is mounted on a corresponding film carrier tape connecting said printed circuit board to said color liquid crystal display.

12. A method for driving a color liquid crystal display by using a data red signal, a data green signal, and a data blue signal obtained by making an individual gamma correction to red data, green data, and blue data being digital video data in order to make corrections so that each of said red data, said green data and said blue data matches a transmittance characteristic of each of red, green, and blue colors for a voltage applied in said color liquid crystal display, said method comprising:

a step of feeding, from a control circuit mounted separately from said color liquid crystal display, during an invalid period having no bearing on a displaying period for said digital video data, information about said gamma correction to be made to said red data, said green data, and said blue data, to a data electrode driving circuit mounted in a vicinity of said color liquid crystal display and to drive said color liquid crystal display by using the data red signal, the data green signal, and the data blue signal obtained by making said gamma correction to said red data, said green data, and said blue data, based on information about said gamma correction to be made to said red data, said green data, and said blue data;

wherein said control circuit is mounted on a printed circuit board attached to an upper portion of a rear of a backlight placed on a rear of said color liquid crystal display and wherein said data electrode driving circuit includes a plurality of data electrode driving sections to provide gray scales by making said gamma correction to said red data, said green data, and said blue data each being corresponding to each of data electrodes of said color liquid crystal display, out of said red data, said green data, and said blue data and converts said gamma-corrected red data, said gamma-corrected green data, and said gamma-corrected blue data into an analog data red signal, an analog data green signal, and an analog data blue signal, such that said analog data red signal, said analog data green signal, and said analog data blue signal are output; and

wherein each of said plurality of said data electrode driving sections is mounted on a corresponding film carrier tape connecting said printed circuit board to said color liquid crystal display.

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专利名称(译)	彩色液晶显示器的驱动电路和驱动方法，以及彩色液晶显示装置		
公开(公告)号	US6727874	公开(公告)日	2004-04-27
申请号	US09/988189	申请日	2001-11-19
申请(专利权)人(译)	NEC公司		
当前申请(专利权)人(译)	NEC公司		
[标]发明人	OKUZONO NOBORU		
发明人	OKUZONO, NOBORU		
IPC分类号	G09G3/36 G02F1/1345 G02F1/133 G09G3/20		
CPC分类号	G09G3/2011 G09G3/3611 G09G3/3688 G09G3/3696 G09G2320/0276		
代理机构(译)	FOLEY＆Lardner的		
优先权	2000353427 2000-11-20 JP		
其他公开文献	US20020060656A1		
外部链接	Espacenet USPTO		

摘要(译)

提供一种彩色液晶显示器的驱动电路，其能够减小基板封装区域并使用公共基板或TCP（带载封装），即使在彩色液晶的分辨率和/或灰度电压的数量时也是如此显示器提供的是不同的，这使得基板，TCP和显示装置能够以低成本制造。在彩色液晶显示器的驱动电路中，数据电极驱动电路基于由灰度信息和灰度电压信息构成的串行数据产生对应于灰度电压特性的灰度电压。