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(54) LIGHTING DEVICE, LIQUID CRYSTAL DISPLAY DEVICE, MOBILE TERMINAL DEVICE AND ITS CONTROLLING METHOD

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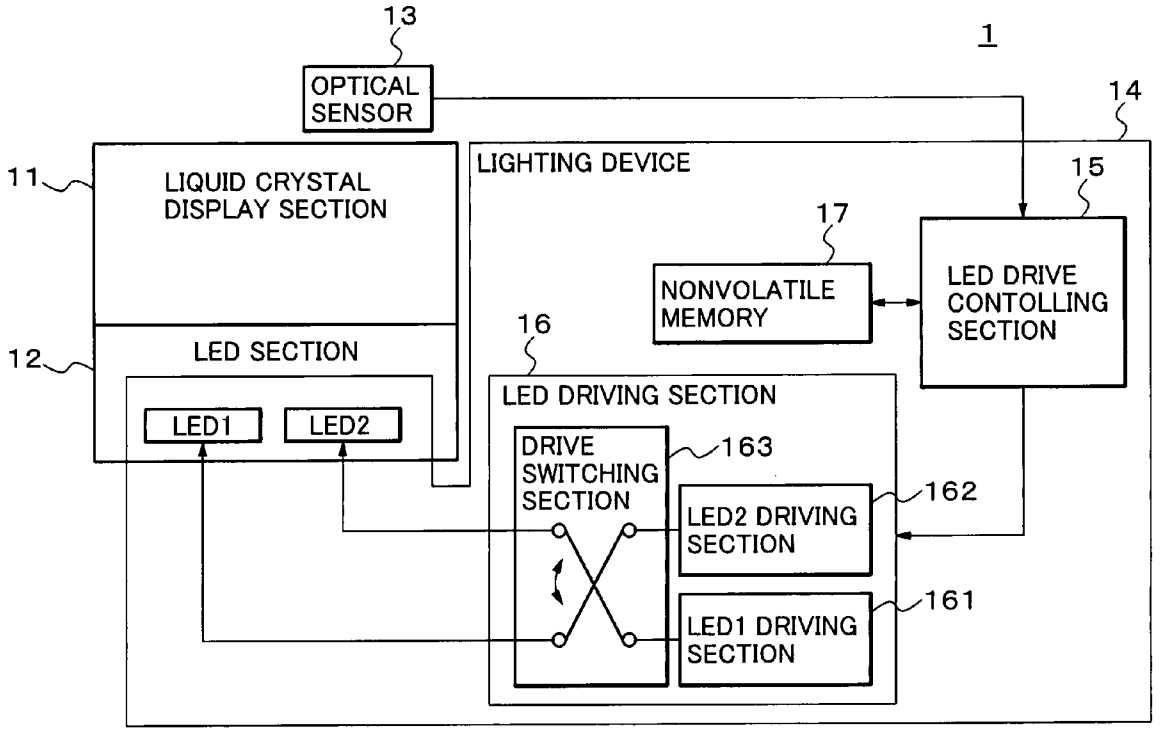
(57) **ABSTRACT**

A lighting device of backlight type that transmits light of a plurality of light emitting elements from a display section includes a plurality of driving sections that drive the plurality of light emitting elements; and drive switching section, provided between the plurality of driving sections and the plurality of light emitting elements, for switching the drive of the plurality of light emitting elements alternately at every fixed cycle.



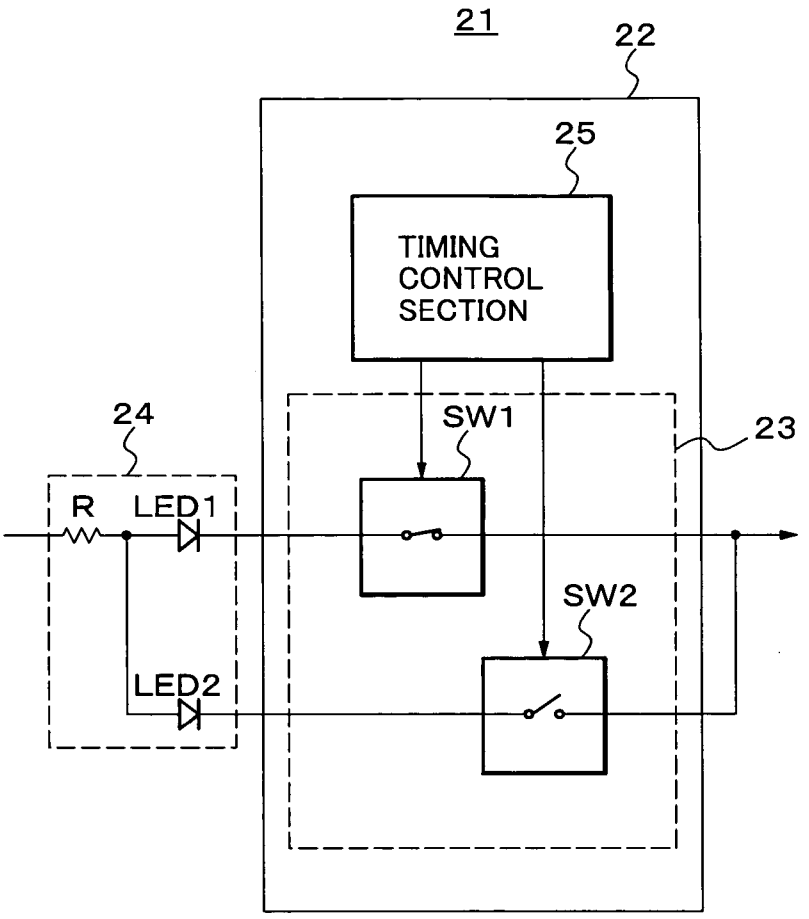


FIG.1A
(PRIOR ART)

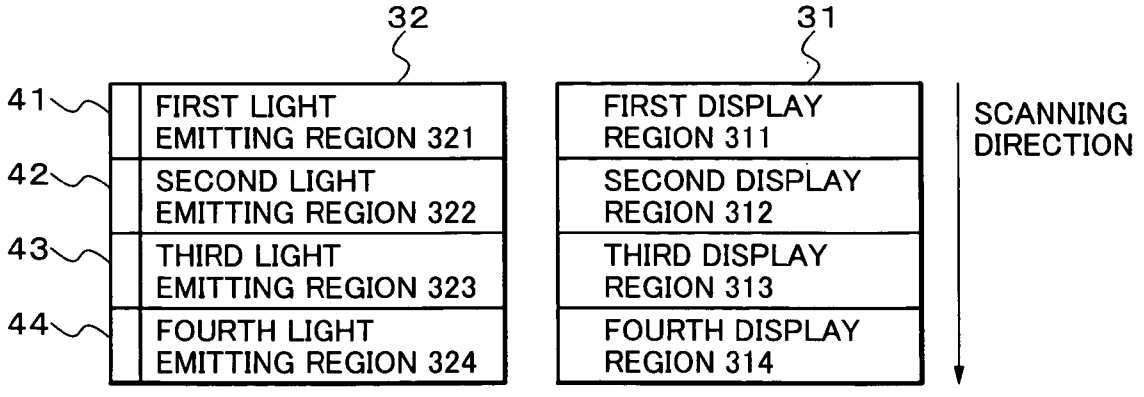


FIG.1B
(PRIOR ART)

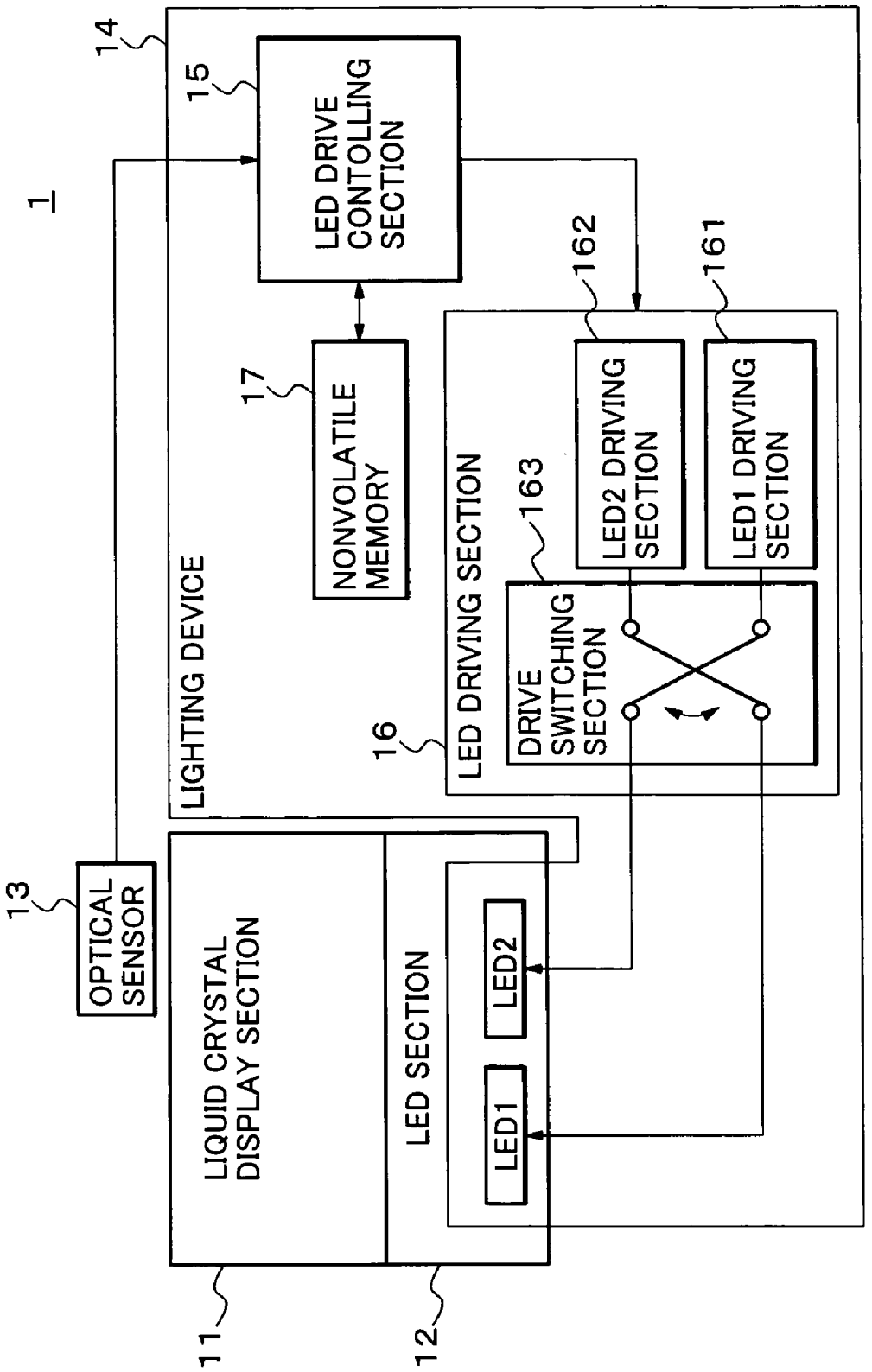

1
14
15
LED DRIVE CONTOLLING SECTION
LIGHTING DEVICE
17
NONVOLATILE MEMORY
162
161
LED2 DRIVING SECTION
LED1 DRIVING SECTION
163
LED DRIVING SECTION
DRIVE SWITCHING SECTION
16
13
OPTICAL SENSOR
LIQUID CRYSTAL DISPLAY SECTION
LED SECTION
LED2
LED1
11
12

FIG.2

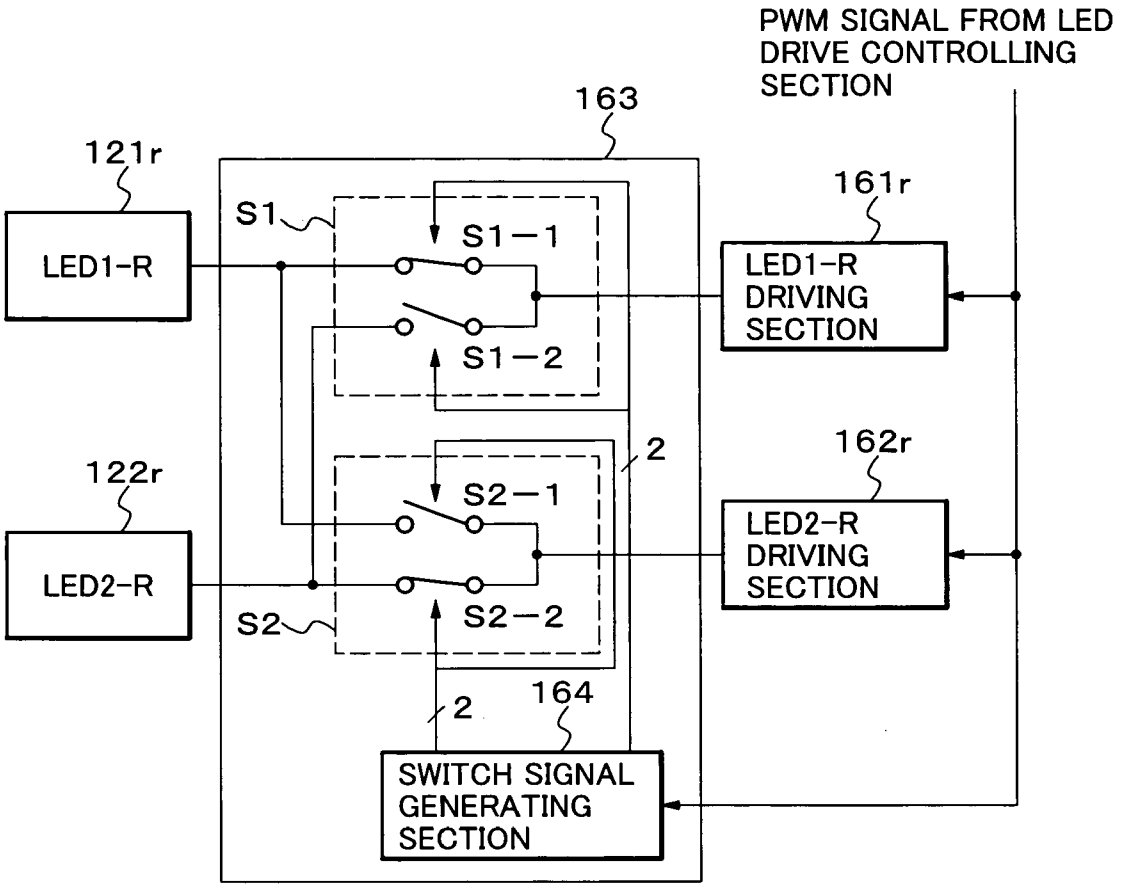

PWM SIGNAL FROM LED DRIVE CONTROLLING SECTION
163
121r
161r
S1
S1—1
LED1-R
LED1-R DRIVING SECTION
S1—2
2
162r
122r
S2—1
LED2-R
LED2-R DRIVING SECTION
S2
S2—2
2
164
SWITCH SIGNAL GENERATING SECTION

FIG.3

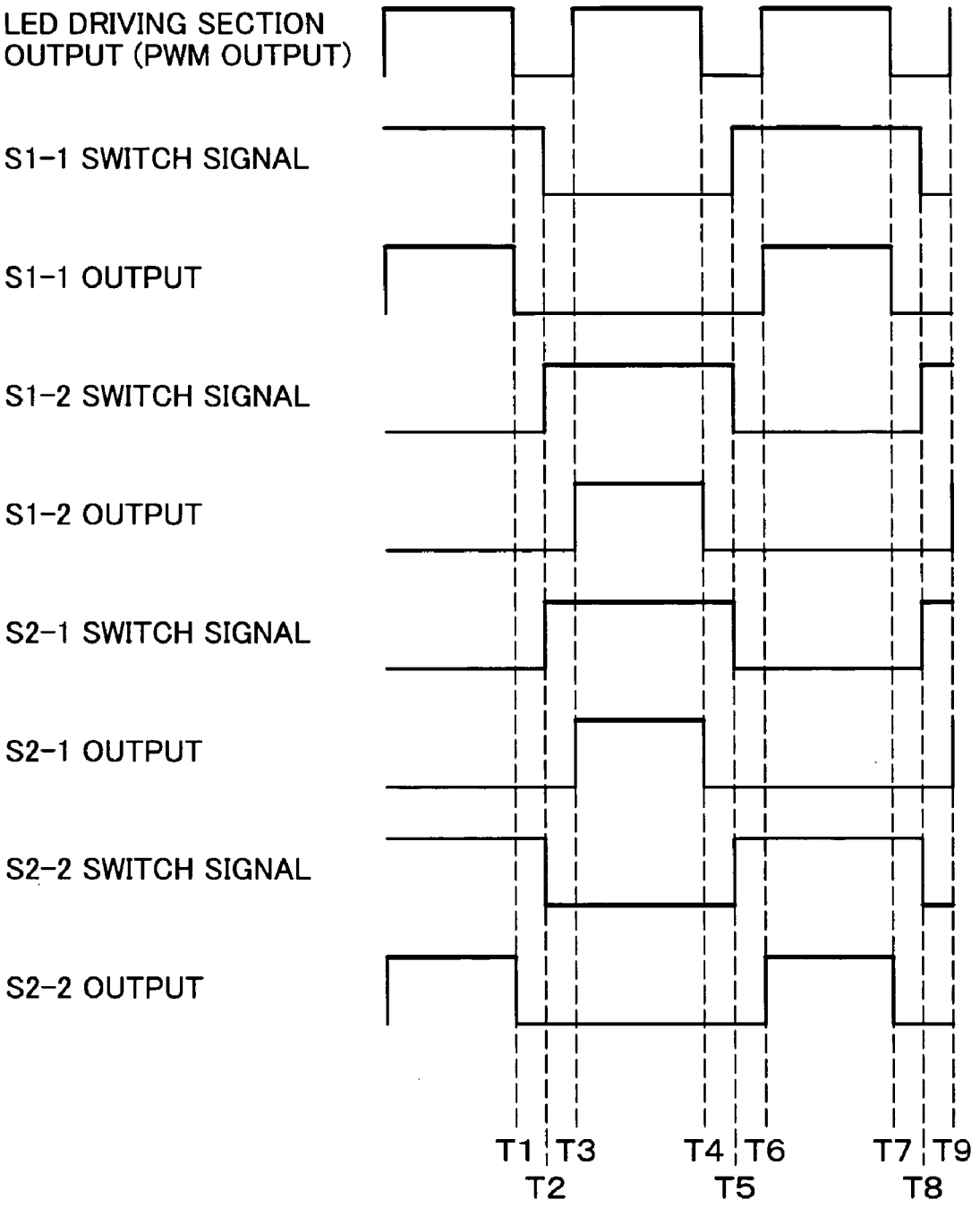

LED DRIVING SECTION OUTPUT (PWM OUTPUT)
S1-1 SWITCH SIGNAL
S1-1 OUTPUT
S1-2 SWITCH SIGNAL
S1-2 OUTPUT
S2-1 SWITCH SIGNAL
S2-1 OUTPUT
S2-2 SWITCH SIGNAL
S2-2 OUTPUT
T1
T2
T3
T4
T5
T6
T7
T8
T9

FIG.4

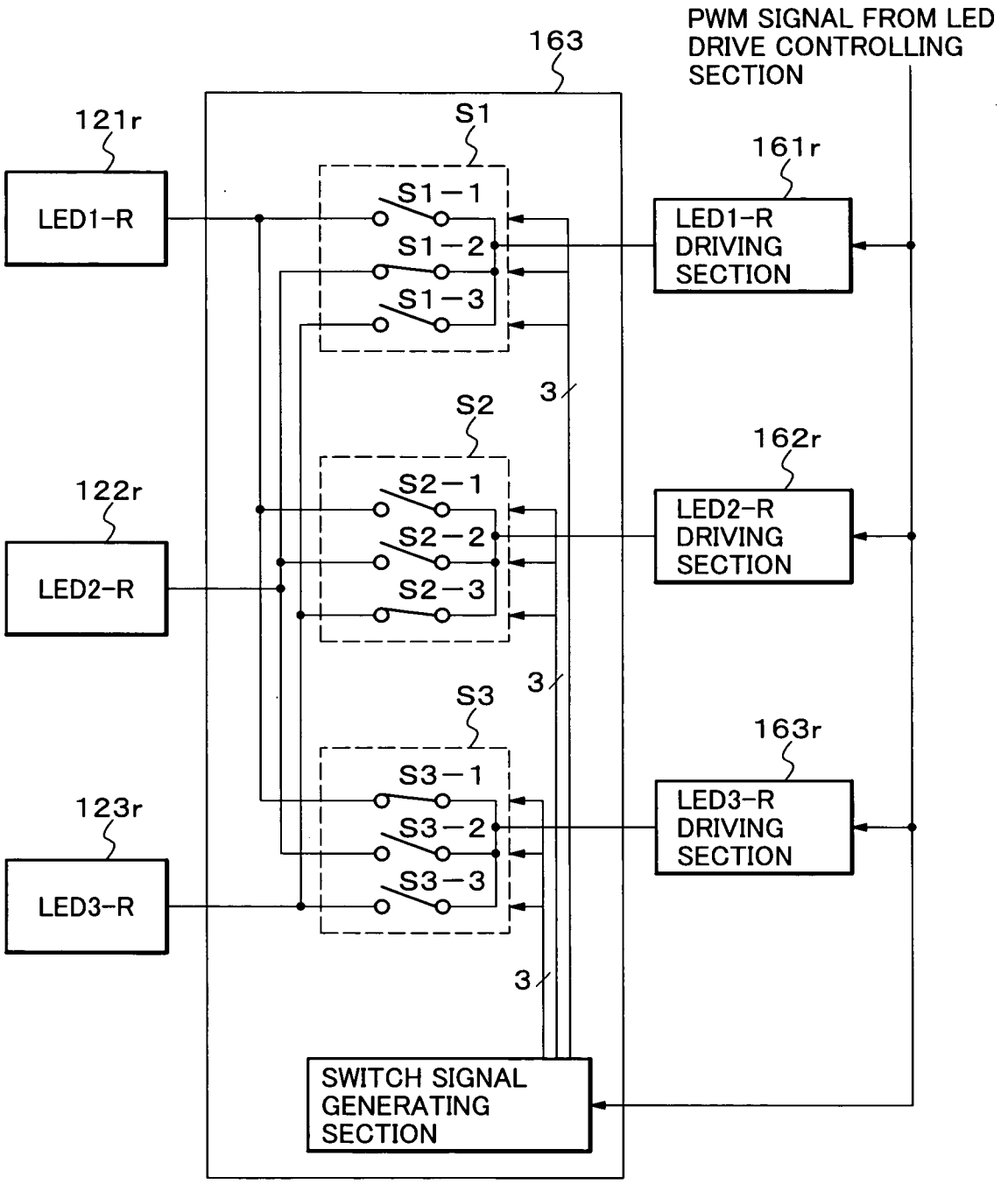

PWM SIGNAL FROM LED DRIVE CONTROLLING SECTION
163
121r
LED1-R
S1
S1-1
S1-2
S1-3
161r
LED1-R DRIVING SECTION
3
S2
122r
LED2-R
S2-1
S2-2
S2-3
162r
LED2-R DRIVING SECTION
3
S3
123r
LED3-R
S3-1
S3-2
S3-3
163r
LED3-R DRIVING SECTION
3
SWITCH SIGNAL GENERATING SECTION

FIG.5

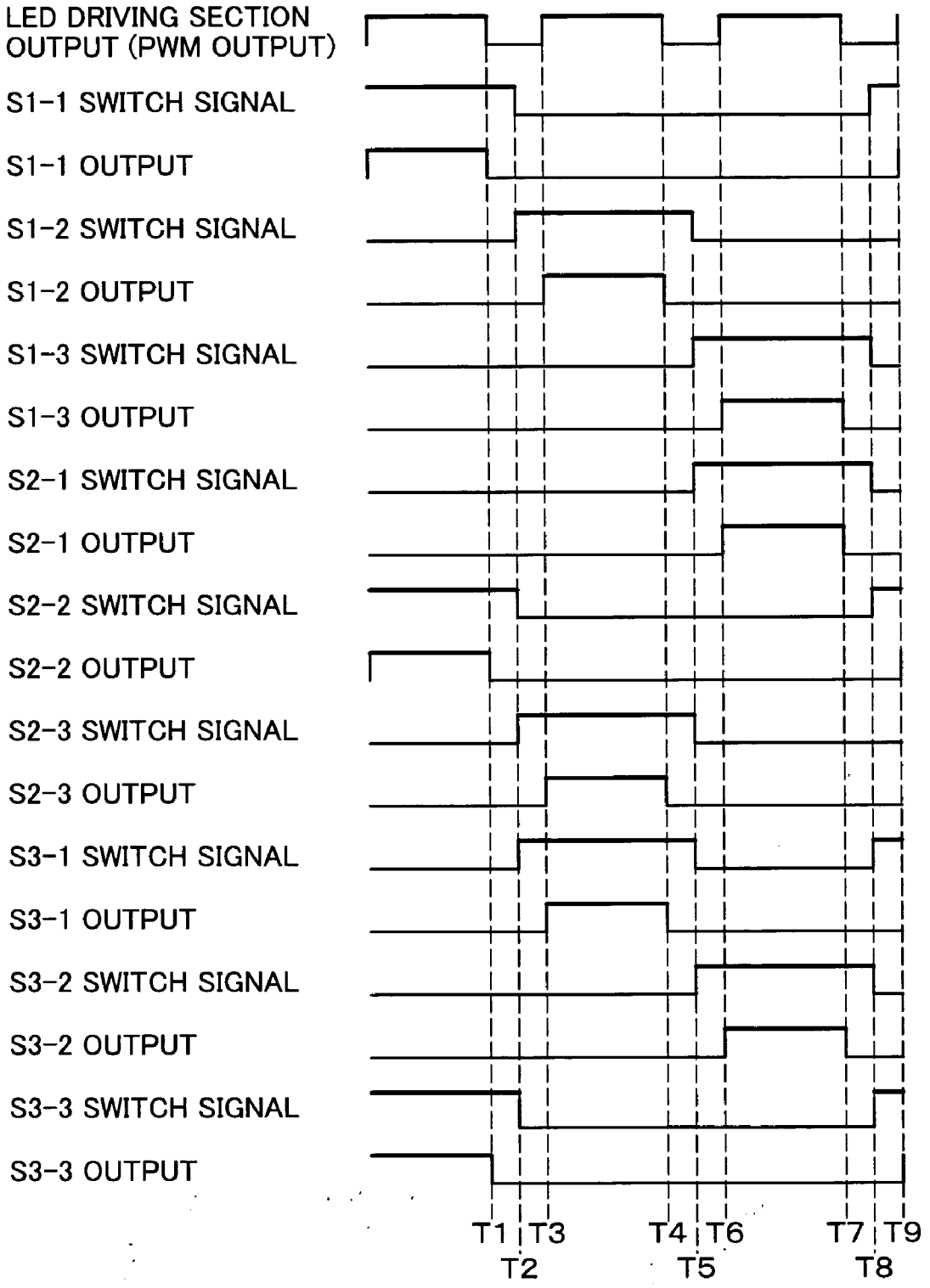

LED DRIVING SECTION OUTPUT (PWM OUTPUT)
S1-1 SWITCH SIGNAL
S1-1 OUTPUT
S1-2 SWITCH SIGNAL
S1-2 OUTPUT
S1-3 SWITCH SIGNAL
S1-3 OUTPUT
S2-1 SWITCH SIGNAL
S2-1 OUTPUT
S2-2 SWITCH SIGNAL
S2-2 OUTPUT
S2-3 SWITCH SIGNAL
S2-3 OUTPUT
S3-1 SWITCH SIGNAL
S3-1 OUTPUT
S3-2 SWITCH SIGNAL
S3-2 OUTPUT
S3-3 SWITCH SIGNAL
S3-3 OUTPUT
T1
T2
T3
T4
T5
T6
T7
T8
T9

FIG.6

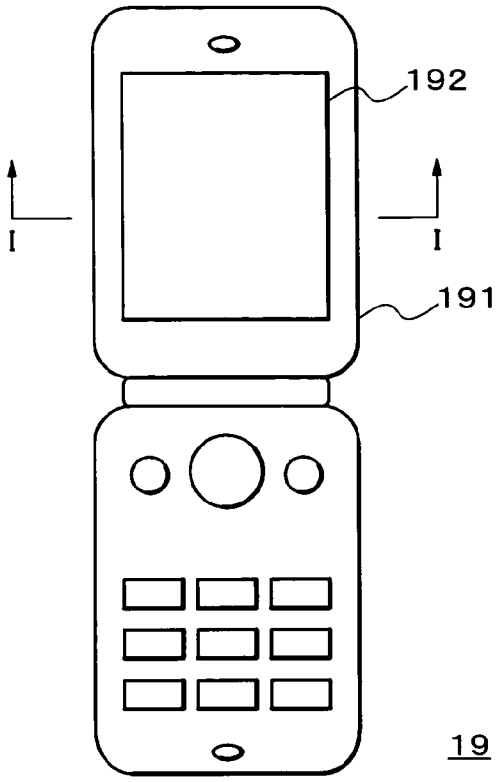

192
I
I
191
19

FIG.7A

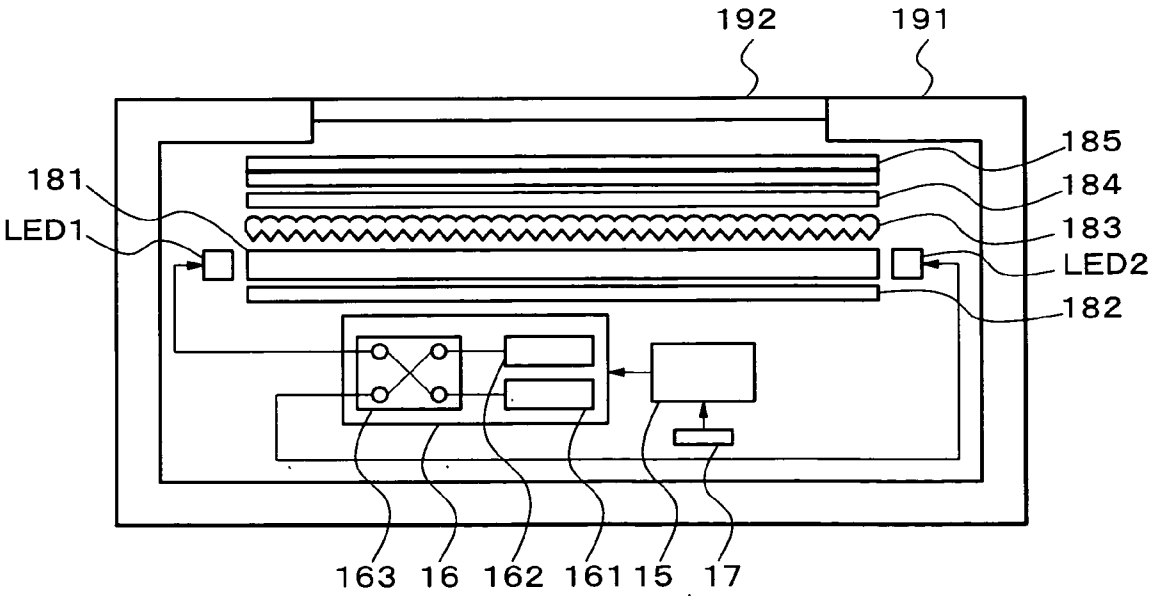

192
191
185
181
184
LED1
183
LED2
182
163
16
162
161
15
17

FIG.7B

LIGHTING DEVICE, LIQUID CRYSTAL DISPLAY DEVICE, MOBILE TERMINAL DEVICE AND ITS CONTROLLING METHOD

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a lighting device, liquid crystal display device, mobile terminal device and its controlling method, and more particularly relates to a lighting device, liquid crystal display device, mobile terminal device and its controlling method by which unevenness of luminance is improved when light emitting elements as backlight are lit.

[0003] 2. Description of the Related Art

[0004] A liquid display device needs an external light source since the liquid display device itself is not a self-luminous display device. A backlight in a lighting device generally refers to a light source provided on a back surface of the liquid crystal display. Especially, in a transmissive liquid crystal display device, the light source is placed on the back surface. For this reason, this light source is referred to as the backlight.

[0005] Conventionally, a cold cathode tube is mainly used as a backlight source. There is also proposed a liquid crystal display device using light emitting diodes (LEDs), which are light emitting elements of red (R), green (G) and blue (B), as a light source, in place of the backlight of the cold cathode tube. In other words, this device is one that displays a color by mixing lights and is called LED backlight.

[0006] In order to display for a large image, a high resolution, a high colorfulness and a high definition are required, and thus projection type devices are mainly used. In these devices, a high performance backlight is required to ensure visibility. In the case of the projection type, an incandescent lamp, LED, electroluminescence (EL), a fluorescent lamp, a metal halide lamp, and the like are used as backlight sources. Among these light sources, the present invention relates LED.

[0007] One example of such conventional backlight systems is proposed in Japanese Patent Laid-Open No. 2002-373795. Referring to **FIG. 1A** illustrating the structure of the proposed backlight system, an LED backlight **24** includes a resistor R, a light emitting diode LED **1**, and a light emitting diode LED **2**. A switching section **23** includes electronic switches SW**1** and SW**2**, and the switch SW**1** or SW**2** is repeatedly turned on and off alternately by a timing signal supplied from a timing control section **25**.

[0008] One in which the electronic switch SW**1** and the light emitting diode LED**1** are connected to each other in series and one in which the electronic switch SW**2** and the light emitting diode LED**2** are connected to each other in series are connected to each other in parallel and the resistor R is connected thereto in series. The timing control section **25** supplies the timing signal to the switch SW**1** and switch SW**2** every ½ of a fixed time cycle (T/2) to control the switches SW**1** and SW**2** to be repeatedly turned on and off alternately.

[0009] Other example relating to the backlight system is proposed in Japanese Patent No. 3584351. In connection with the backlight system proposed here, there is shown a liquid crystal display device of colored light source type that causes a three-color backlight to be emitted in a time divisional manner to perform full color display. Referring to **FIG. 1B**, a light emitting region **32** is divided into a plurality of regions **321** to **324**. In this document, the following feature is described. Based on recognition that light emission intensity differs for the scanning start region and the scanning end region, each divided light emitting region are different from each other in light transmittance due to the characteristic problem of the liquid crystal panel itself even if the same voltage is applied thereto. As illustrated in **FIG. 1B**, for the purpose of improving the unevenness of luminance in hypothetically divided display regions **311** to **314**, the light emitting region is divided into the plurality of regions and light emission intensity is made different for each divided light emitting region.

[0010] Next, assume a backlight unit that includes plural combinations of LEDs as light sources and driving unit for the LEDs. In the case where the technique described in the aforementioned Japanese Patent Laid-Open No. 2002-373795 is applied to this backlight unit, plural switching sections and their driving section are provided. In this case, when there is an output difference between the driving sections, variations in LED luminance occur. Accordingly, variations in luminance also occur in the inner surface of the backlight using the LEDs. However, this document does not disclose anything about its improving method.

[0011] Meanwhile, in Japanese Patent No. 3584351, it is described that unevenness of luminance occurs since the scanning start region and the scanning end region are different from each other in light transmittance due to the characteristic problem of the liquid crystal panel itself even if the same voltage is applied thereto. For the purpose of improving the unevenness of luminance, the light emitting region is divided into the plurality of regions and light emission intensity is made different for each divided light emitting region. However, this does not take measures against the unevenness of luminance in each divided light emitting region, resulting in difficulty to provide light emission intensity to each light emitting region in details.

SUMMARY OF THE INVENTION

[0012] Accordingly, an exemplary feature of the present invention is to reduce unevenness of luminance of a backlight caused by unevenness of luminance generated among light emitting elements that is a problem of the aforementioned conventional backlight system.

[0013] Namely, the exemplary feature of the present invention is to provide a lighting device, liquid crystal display device, mobile terminal device and its controlling method for which improvement is performed to prevent occurrence of luminance unevenness of a backlight even if there is a capability difference between driving sections that drive individual light emitting elements (for example, LEDs).

[0014] A lighting device according to the present invention is a lighting device of backlight type that transmits light of a plurality of light emitting elements from a display section includes a plurality of driving sections that drive the plurality of light emitting elements; and drive switching section, provided between the plurality of driving sections

and the plurality of light emitting elements, for switching the drive of the plurality of light emitting elements alternately at every fixed cycle.

[0015] Preferably, at least one light-off time is provided within one frame period during which one screen is displayed on the display section and the drive of the light emitting elements is switched within the light-off time.

[0016] Preferably, the drive switching section controls the switching of the plurality of light emitting elements alternately using a plurality of drive control signals each having a different timing.

[0017] Preferably, the lighting device of the present invention further includes switch signal generating section for supplying a switch signal to the drive switching section, wherein the drive switching section alternately switches the plurality of light emitting elements and the plurality of driving sections respectively to be connected to each other and to adjust an output difference between the driving sections according to a level change from inactive to active in the drive control signal.

[0018] Preferably, the drive switching section is a plurality of switches.

[0019] Preferably, the plurality of light emitting elements are respectively driven alternately as maintaining a lighting state.

[0020] Preferably, the plurality of driving sections drive the plurality of light emitting elements by pulse width modulation (PWM) dimming and the drive switching section switches the drive of the light emitting elements during the light-off time in PWM dimming.

[0021] A liquid crystal display device according to the present invention includes a liquid crystal display section, a lighting device of backlight type that transmits light of a plurality of light emitting elements from a display section and that has a plurality of driving sections that drive the plurality of light emitting elements, and drive switching section, provided between the plurality of driving sections and the plurality of light emitting elements, for switching the drive of the plurality of light emitting elements alternately at every fixed cycle.

[0022] Preferably, the drive switching section of the lighting device controls the switching, of the plurality of light emitting elements alternately using a plurality of drive control signals each having a different timing.

[0023] Preferably, the liquid crystal display device further includes switch signal generating section for supplying a switch signal to the drive-switching section of the lighting device, wherein the drive switching section alternately switches the plurality of light emitting elements and the plurality of driving sections respectively to be connected to each other and to adjust an output difference between the plurality of driving sections according to a level change from inactive to active in the drive control signal.

[0024] A mobile terminal device of the present invention includes a liquid crystal display section; and a lighting device of backlight type that transmits light of a plurality of light emitting elements from a display section and that has a plurality of driving sections that drive the plurality of light emitting elements; and drive switching section, provided between the plurality of driving sections and the plurality of light emitting elements, for switching the drive of the plurality of light emitting elements alternately at every fixed cycle.

[0025] Preferably, the drive switching section controls the switching of the plurality of light emitting elements alternately using a plurality of drive control signals each having a different timing.

[0026] Preferably, the mobile terminal device further includes switch signal generating section for supplying a switch signal to the drive switching section of the lighting device, wherein the drive switching section alternately switches the plurality of light emitting elements and the plurality of driving sections respectively to be connected to each other and to adjust an output difference between the plurality of driving sections according to a level change from inactive to active in the drive control signal.

[0027] Preferably, the drive switching section of the lighting device is a plurality of switches and the switch signal generating section of the lighting device is a switch signal generating section.

[0028] A method for controlling a lighting device according to the present invention that transmits light of a plurality of light emitting elements from a back surface of a display section includes the lighting device having a plurality of driving sections that drive the plurality of light emitting elements, a plurality of current switching sections provided between the plurality of driving sections and the plurality of light emitting elements, and a switch signal generating section that supplies a switch signal to the current switching section, wherein the steps of alternately switching the plurality of light emitting elements and the plurality of driving sections respectively to be connected to each other by each of the plurality of current switching section according to a level change from inactive to active in the drive control signal and causing sense section to detect light of the light emitting elements lit alternately according to the switching and connection to control switching of emission of the light emitting elements based on the detection result by the current switching section are included.

[0029] Preferably, the method of the present invention further includes the step of switching the drive of the light emitting elements by the current switching section at a predetermined fixed cycle and within light-off time.

[0030] Preferably, the method of the present invention further includes the step of adjusting an output difference between the driving sections of the light emitting elements by switching the light emitting elements alternately according to a switch signal of the plurality of current switching section each having a different timing.

[0031] Preferably, the method of the present invention further includes the luminance unevenness reduction step of adjusting an output difference between the plurality of driving sections by alternately switching the plurality of light emitting elements and the plurality of driving sections to be connected to each other according to a level change from inactive to active in the drive control signal.

[0032] Preferably, the method of the present invention further includes the step of adjusting an output difference between the driving sections by alternately switching the

plurality of current switching section to be connected to the light emitting elements by the plurality of driving sections according to a level change from inactive to active in the drive control signal.

[0033] Preferably, the method of the present invention further includes the step of alternately driving each of the plurality of light emitting elements by at least two or more driving sections according to a level change from inactive to active in the drive control signal.

[0034] Preferably, the method of the present invention further includes the step of alternately driving each of the plurality of light emitting elements by the driving sections while maintaining a lighting state according to a level change from inactive to active in the drive control signal.

[0035] According to the lighting device of the present invention, the drive switching section alternately switches the drive of the plurality of light emitting elements using the plurality of driving sections at every fixed cycle. This drives the plurality of light emitting elements equally to make it possible to equalize luminance of plural light emitting elements even if there is a difference in drive capability among the plural driving sections.

[0036] According to the liquid crystal display device of the present invention,. the drive switching section of the lighting device alternately switches the drive of the plurality of light emitting elements using the plurality of driving sections at every fixed cycle. This drives the plurality of light emitting elements equally to make it possible to equalize luminance of plural light emitting elements even if there is a difference in drive capability among the plural driving sections. Accordingly, it is possible to reduce the unevenness of the display image resulting from the lighting device.

[0037] According to the mobile terminal device of the present invention, the drive switching section of the lighting device alternately switches the drive of the plurality of light emitting elements using the plurality of driving sections at every fixed cycle. This drives the plurality of light emitting elements equally to make it possible to equalize luminance of plural light emitting elements even if there is a difference in drive capability among the plural driving sections. Accordingly, it is possible to reduce the unevenness of the display image resulting from the lighting device.

[0038] According to the lighting device controlling method of the present invention, the plurality of light emitting elements and the plurality of driving sections are alternately switched to be connected to each other and to detect light of lit by the light emitting elements, so that the switching of the emission of light emitting elements is controlled based on the detection result. This drives the plurality of light emitting elements equally to make it possible to equalize luminance of plural light emitting elements even if there is a difference in drive capability among the plural driving sections.

BRIEF DESCRIPTION OF THE DRAWINGS

[0039] These and other objects and advantages and further description of the invention will be more apparent to those skilled in the art by reference to the description, taken in connection with the accompanying drawings, in which:

[0040] **FIG. 1A** is a block diagram illustrating one example of a conventional backlight system;

[0041] **FIG. 1B** is a schematic view illustrating a divisional state of each of a light emitting region, an LED array, and a liquid crystal panel in connection with the conventional backlight system;

[0042] **FIG. 2** is a block diagram of a liquid crystal display device on which a lighting device of the present invention is mounted;

[0043] **FIG. 3** is a block diagram of LED driving sections in the lighting device according to a first exemplary embodiment of the present invention;

[0044] **FIG. 4** is a timing chart for explaining an operation according to the first exemplary embodiment of the present invention;

[0045] **FIG. 5** is a block diagram of drive switching sections **163** for driving R(Red)-LEDs when the number of LED driving sections is three according to a second exemplary embodiment of the present invention;

[0046] **FIG. 6** is a timing chart for explaining an operation according to the second exemplary embodiment of the present invention;

[0047] **FIG. 7A** is an external view of a mobile terminal device into which the main structures of the liquid crystal device of **FIG. 2** are incorporated; and

[0048] **FIG. 7B** is a cross-sectional view taken along a line I-I of **FIG. 7A**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0049] Next, embodiments of the present invention will be specifically explained with reference to the drawings.

[0050] First of all, the following will specifically explain a liquid crystal display device according to a first exemplary embodiment of the present invention with reference to the drawings.

[0051] Referring to **FIG. 2**, a liquid crystal display device **1** includes a liquid crystal display section **11** that is configured with a plurality of liquid crystal display devices, an LED section **12** having light emitting elements for a backlight of liquid crystal display devices, an optical sensor **13**, and a lighting device **14** that controls the backlight in response to a detection result of the optical sensor **13**.

[0052] In other words, the liquid crystal display device **1** has the LED section **12** including plural LED**1** and LED**2**, which are light emitting elements for backlight to transmit light of the light emitting elements arranged on a back surface of the liquid crystal display section **11** from, the liquid crystal display section **11** to make it easy to see the liquid crystal display.

[0053] Moreover, the liquid crystal display device **1** has the optical sensor **13** that detects brightness of the backlight from a screen of the liquid crystal display section **11** and the, lighting device **14** that performs optical feedback control to control emission of the LED**1** and LED**2** of the LED section **12** upon, reception of the detection result of the optical sensor **13**.

[0054] The lighting device **14** includes an LED drive controlling section **15**, an LED driving section **16**, and a

nonvolatile memory **17**. The nonvolatile memory **17** stores an initial value of PWM (Pulse Width Modulation) for LED.

[**0055**] Namely, first of all, an operation, such as how many PWM values should be output or writing and reading of a PWM value for emitting light at a predetermined color temperature, is performed between the nonvolatile memory **17** and the LED drive controlling section **15** when power is turned on.

[**0056**] It is assumed that a PWM signal from the LED drive controlling section **15** has the same output timing as an R output of the LED driving section **16** to be described in **FIG. 4** and that has a waveform same as that of the R output while having a different level value.

[**0057**] The LED driving section **16** includes a driving section **161** for LED**1**, a driving section **162** for LED**2**, and a drive switching section **163**. The PWM signal is sent to the respective blocks in common from the LED drive controlling section **15**.

[**0058**] Referring to **FIG. 3** that shows a block diagram of the LED driving section **16**, a case is shown where the drive of the red (R) LED is switched as one example.

[**0059**] The drive switching section **163** has a switch S**1** that selectively switches a driving current from an LED**1**-R **161***r* and supplies the current to an LED**1**-R in order to drive the LED section **12**. Moreover, the drive switching section **163** has a switch S**2** that selectively switches a driving current from an LED**2**-R **162***r* and supplies the current to an LED**2**-R. Furthermore, the drive switching section **163** has a switch signal generating section **164** that generates a switch control signal for controlling the opening/closing of the switches S**1** and S**2**.

[**0060**] Under control of the switch signal generating section **164**, the switch S**1** outputs the driving current supplied by the LED**1**-R driving section **161***r* to the LED**1**-R(Red) and the LED**2**-R(Red) alternately.

[**0061**] Similarly, under control of the switch signal generating section **164**, the switch S**2** outputs the driving current supplied by the LED**2**-R driving section **162***r* to the LED**2**-R(Red) and the LED**1**-R(Red) alternately.

[**0062**] In other words, the switch S**2** selectively outputs one input current from the corresponding output terminal via two switches S**2-1** and S**2-2** alternately by the switch signal from the switch signal generating section **164**.

[**0063**] A specific operation will be explained with reference to **FIG. 3** and **FIG. 4** that shows a timing chart for explaining the operation in the first embodiment.

[**0064**] First of all, it is assumed that switch S**1-1** is in a high level (hereinafter referred to as on state) of a logical level, switch S**1-2** is in a low level (hereinafter referred to as off state) , switch S**2-1** is in an off state, and the switch S**1-2** is in an on state. The driving current (R output) inputted to the switch S**1** from the LED**1**-R driving section is divided into the switches S**1-1** and S**1-2** respectively and supplied thereto as a common input. It is assumed that drive capability of the driving current (R output) supplied at this time is a P value.

[**0065**] The PWM output is in an on state until timing T**1** and the switch S**1-1** is also in an on state, so that the R output drives the LED**1**-R from the first output terminal using a high-level P value accordingly.

[**0066**] Meanwhile, the R output inputted to the switch S**2** from the LED**2**-R driving section is divided into the switches S**2-1** and S**2-2** respectively and supplied thereto as a common input similar to the switch S**1**. It is assumed that drive capability of the driving current (R output) supplied at this time is a Q value that is different from the P value. Although P value may be equal to Q value, the different value is used here.

[**0067**] The PWM output is in an on state until timing T**1** as mentioned above, and the switch S**2-2** is also in an on state. Therefore, the R output drives the LED**2**-R from the output terminal of switch S**2-2** using a high-level P value.

[**0068**] Next, the PWM output is in an off state until timing T**3** after T**1**. At timing T**2** during this time period, the switch S**1-1** is changed to off, the switch S**1-2** is changed to on, the switch S**2-1** is changed to on, and the switch S**2-2** is changed to off.

[**0069**] The R output, inputted to the switch S**1** from the LED**1**-R driving section **161***r*, is supplied to the switches S**1-1** and S**1-2** as a common input. It is assumed that drive capability of the driving current (R output) supplied at this time is maintained at, for example, a P value. In the present invention, there is, of course, no problem in canceling the level difference even if the P value is changed.

[**0070**] The switch S**1-2** is changed to on, so that the R output drives the LED**2**-R from the output terminal of S**1-2** using a high-level P value at timing T**3** accordingly.

[**0071**] Meanwhile, the R output, inputted to the switch S**2** from the LED**2**-R driving section **162***r*, is divided into the switches S**2-1** and S**2-2** respectively and supplied thereto as a common input similar to the switch S**1**. It is assumed that drive capability of the driving current (R output) supplied at this time is also a Q value.

[**0072**] The PWM output is in an on state until timing T**4** as mentioned above, and the switch S**2-1** is also in an on state. Therefore, the R output drives the LED**1**-R from the output terminal of the switch S**2-1** using a high-level Q value.

[**0073**] The aforementioned switching operation is repeated in synchronization with a predetermined PWM output cycle. Namely, regarding the switches S**1** and S**2**, the switch S**1** selectively outputs one input current from the corresponding output terminal via two switches S**1-1** and S**1-2** alternately, using the switch signal from the switch signal generating section **164**.

[**0074**] Alternatively, the switch S**2** selectively outputs one input current from the corresponding output terminal via two switches S**2-1** and S**2-2** alternately. In other words, two LEDs are alternately driven by one driving section and one LED is driven by two driving sections alternately.

[**0075**] This switching operation alternately drives the respective LEDs at a fast cycle using the P value and Q value in such a manner to prevent flicker becoming noticeable. The frequency of the switching operation is set about ten times as high as the frame frequency, that is, about 600 Hz. Even if there is a difference in the drive capability (even if the P value and Q value are different from each other), the

emission luminance of LEDs becomes equal, and no difference in the drive capability can be observed. Neither switch **S1** nor **S2** is turned on simultaneously using their internal switches are used. In other words, control is made in such a manner that **S1-1** and **S2-2** reach the same logical level and the **S1-2** and **S2-1** reach the same logical level.

[0076] In connection with each color of R, G, B, these operations are repeated at a frequency at which no flicker appears, so that the emission luminance of LEDs becomes equal. The backlight unit using these LEDs as light sources can reduce unevenness of luminance of the surface.

[0077] The drive switching section **16-3**, which is peculiar to the present invention having the switching operation by the switches **S1** and **S2** as mentioned above, has at least light-off time within one frame period during which one screen is displayed on the display section. The drive of the light emitting element is switched within the light-off time. The frame frequency is several tens Hz, for example, 60 Hz or 70 Hz, and depends on display resolution. In other words, the drive switching section **163** has an operation function to change the switches **S1** and **S2** during the time when the PWM output of the LED driving section is in the low level of the logical level. For this reason, the drive switching section **163** is switched at high speed, and luminance is thereby equalized and viewed.

[0078] Accordingly, in the present invention, since the outputs of the plural LED driving sections are changed to equalize the outputs even if there is the output difference between the plural LED driving sections, it is possible to reduce unevenness of luminance caused by variations in the outputs of the LED driving sections. Moreover, even if there are variations in the output current values of the plural drive power sources, the variations are equalized since the output current values are alternately changed by the plural driving sections, thereby allowing a reduction in unevenness of luminance.

[0079] Furthermore, this eliminates the need for making an adjustment to the outputs of the LED driving sections using a luminance meter and the like, thereby contributing to a reduction in cost. Moreover, since the variations are equalized, there is no need of a step for adjusting the variations in the output current of the LED driving sections using an output amount adjusting section such as a volume, etc., thereby contributing to a reduction in production cost.

[0080] Still moreover, at least one light-off time is provided within one frame time, and the drive of light emitting element is switched alternately by the plural driving sections within the light-off time at a predetermined fixed cycle. Accordingly, noise caused by switching the drive is not noticeable within one frame display time and no noise erasing circuit is needed.

[0081] Next, an explanation will be specifically given of a liquid crystal display device according to a second exemplary embodiment of the present invention with reference to the drawings.

[0082] Although the number of LED driving sections is two, that is, LED**1** driving sections **161** and **162** in the aforementioned first embodiment, the following will explain that the same effect can be obtained even if the number of LED driving sections and that of LEDs of the LED section **12** are three or more respectively.

[0083] The on and off states of the switches **S1**, **S2**, and **S3** illustrated in **FIG. 5** indicate states between timing T**2** to T**5** in **FIG. 6** described later as one example.

[0084] Referring to **FIG. 5**, the second embodiment differs from the first embodiment in the point that an LED**3**-R driving section **163***r*, a switch **S3**, and an LED**3**-R of the LED section **12** are added. Namely, the drive switching section **163** includes three switches **S1**, **S2**, and **S3** and the switch signal generating section **164**, and the switches **S1**, **S2** and **S3** have three independent outputs for one input. The LED drive controlling section **15** supplies a PWM signal to the LED**1**-R driving section **161***r*, LED**2**-R driving section **162***r*, and LED**3**-R driving section **163***r* in common respectively. Moreover, the opening/closing of the switches **S1**, **S2**, and **S3** are alternately controlled by the switch signal from the switch signal generating section **164**.

[0085] A specific operation will be explained with reference to **FIG. 5** and **FIG. 6** that shows a timing chart for explaining the operation in the second embodiment. The switches **S1-1**, **S1-2**, and **S1-3** of the switch **S1** are respectively controlled in synchronization with the PWM signal by the switch signal from the switch signal generating section **164** in such a manner that these switches are turned on independently of one another without being turned on simultaneously. Similarly, the switches **S2** and **S3** are also respectively controlled in such a manner that these switches are turned on independently of one another without being turned on simultaneously. Moreover, regarding the switches with the same number among the switches **S1**, **S2** and **S3**, for example, two or more switches of **S1-1**, **S1-2** and **S1-3** are controlled not to be turned on simultaneously.

[0086] First, the PWM output is in an on state until timing T**1** and the switch **S1-1** of the switch **S1** is in an on state and other switches **S1-2** and **S1-3** are in an off state. In the switch **S2**, the switch **S2-2** is in an on state and other switches **S2-1** and **S2-3** are in an off state. In the switch **S3**, the switch **S3-3** is in an on state and other switches **S3-2** and **S3-2** are in an off state.

[0087] The switch **S1-1** is in an on state, so that the driving current (R output) inputted to the switch **S1** from the LED**1**-R driving section **161***r* is divided into the switches **S1-1** to **S1-3** respectively and supplied thereto as a common input. It is assumed that drive capability of the driving current (R output) supplied at this time is an R value. The switch **S1-1** is also in an on state, so that the R output drives the LED**1**-R from the output terminal of **S1-1** using a high-level R value accordingly.

[0088] On one hand, the R output inputted to the switch **S2** from the LED**2**-R driving section **162***r* is divided into the switches **S2-1** and **S2-3** respectively and supplied thereto as a common input similar to the switch **S1**. It is assumed that drive capability of the driving current (R output) supplied at this time is an S value that is different from the R value. Although R value maybe equal to S value, the different value is used here. The PWM output is in an on state until timing T**1** and the switch **S2-2** is also in an on state, so that the R output drives the LED**2**-R from the first output terminal of **S2-2** using a high-level R value accordingly.

[0089] On the other hand, the R output inputted to the switch **S3** from the LED**3**-R driving section **163***r* is divided into the switches **S3-1** to **S3-3** respectively and supplied

thereto as a common input similar to the switch S1. It is assumed that drive capability of the driving current (R output) supplied at this time is a T value that is different from the S value. Although R value, S value and T value may be equal to each other, the different values are used here respectively. The PWM output is in an on state until timing T1 and the switch S3-3 is also in an on state, so that the R output drives the LED3-R from the output terminal of S3-3 using a high-level R value accordingly.

[0090] Next, the PWM output is in an off state until timing T3 after T1. At timing T2 during this time period, the switch S1-1 is changed from on to off, the switch S1-2 is changed from off to on, and the switch S1-3 is maintained in the off state. The switch S2-1 is maintained in the off state, the switch S2-2 is changed from on to off, and the switch S2-3 is changed from off to on. The switch S3-1 is changed from off to on, the switch S3-2 is maintained in the off state, and the switch S3-3 is changed from on to off.

[0091] The R output, inputted to the switch S1 from the LED1-R driving section **161***r* where the PWM output is in an on state until timing T4 after T3, is supplied to the switches S1-1 and S1-2 as a common input. The switch S1-2 is changed to an on state, so that the R output drives the LED2-R from the output terminal of S1-2 using a high-level P value at timing T3 accordingly.

[0092] On one hand, the R output inputted to the switch S2 from the LED2-R driving section **162***r* is divided into the switches S2-1, S2-2, and S2-3 respectively and supplied thereto as a common input similar to the switch S1. The switch S2-3 is changed to an on state, so that the R output drives the LED3-R from the output terminal of S2-3 using a high-level P value at timing T3 accordingly.

[0093] On one hand, the R output inputted to the switch S3 from the LED3-R driving section **163***r* is divided into the switches S3-1, S3-2, and S3-3 respectively and supplied thereto as a common input similar to the switch S1. The switch S3-1 is changed to an on state, so that the R output drives the LED1-R from the output terminal of S3-1 using a high-level P value at timing T3 accordingly.

[0094] The PWM output is in an off state until timing T4 to T6. At timing T5 during this time period, the switch S1-1 is maintained in an off state, the switch S1-2 is changed from on to off, and the switch S1-3 is changed from off to on. The switch S2-1 is changed from off to on, the switch S2-2 is maintained in the off state, and the switch S2-3 is changed from on to off. The switch S3-2 is changed from on to off, the switch S3-2 is changed from off to on, and the switch S3-3 is maintained in the off state.

[0095] The R output, inputted to the switch S1 from the LED1-R driving section **161***r* where the PWM output is in an on state until timing T7 after T6, is supplied to the switches S1-1, S1-2, and S1-3 as a common input. The switch S1-3 is changed to an on state, so that the R output drives the LED3-R from the output terminal of S1-3 using a high-level P value at timing T6 accordingly.

[0096] On one hand, the R output inputted to the switch S2 from the LED2-R driving section **162***r* is divided into the switches S2-1, S2-2, and S2-3 respectively and supplied thereto as a common input similar to the switch S1. The switch S2-1 is changed to an on state, so that the R output drives the LED1-R from the output terminal of S2-1 using a high-level P value at timing T6 accordingly.

[0097] On one hand, the R output inputted to the switch S3 from the LED3-R driving section is divided into the switches S3-1, S3-2, and S3-3 respectively and supplied thereto as a common input similar to the switch S1. The switch S3-2 is changed to an on state, so that the R output drives the LED2-R from the output terminal of S3-2 using a high-level P value at timing T6 accordingly.

[0098] The aforementioned switching operation is repeated in synchronization with a predetermined PWM output cycle.

[0099] In the second embodiment, the same effect as the first embodiment can be obtained.

[0100] In other words, each of the switches S1 to S3 selectively outputs one input current from the corresponding output terminal via three switches (S1-1 to S1-3, S2-1 to S2-3, or S3-1 to S3-3) alternately using the switch signal from the switch signal generating section **164**. Namely, three LEDs are alternately driven by one driving section and one LED is driven by three driving sections alternately.

[0101] This switching operation alternately drives the respective LEDs at a fast cycle using R value, S value, and T value even if there is a difference in the drive capability (even if the P value, S value, and T value are different from one another). As a result, the emission luminance of LEDs becomes equal, and no difference is found in the drive capability.

[0102] Accordingly, in the case where the number of LED driving sections is n, n switches with one input and n outputs are prepared, allowing the embodiment of the present invention to be structured.

[0103] Although the preferred embodiments of the present invention have been explained as mentioned above, the present invention is not limited to the above embodiments, and various changes and applications may be made. For example, although the above first and second embodiments have been explained based on the structure of the semiconductor switch, it is apparent that the present invention may be structured using a semiconductor relay and the like.

[0104] Moreover, although the above has explained the case in which LEDs are used as light emitting elements, the present invention may be applied to any case if the lighting device uses the light emitting elements of current drive type. For example, the present invention may be also applied to a case in which organic light emitting elements (OLED) are used as light emitting elements.

[0105] Furthermore, in displaying the screen of the liquid crystal display device, the present invention may be applied so that drive current of the driving section may be changed one line by one at a PWM dimming time. In other words, this is the most effective way in terms of the equalization of luminance in the screen since one line is the minimum unit of switching and there is adequate time to switch current during the off time period of the PWM signal.

[0106] Moreover, as another example in which the present invention is applied in displaying the screen of the liquid crystal: display device, drive current of the driving section may be switched every plural lines at the time of using a

blinking backlight for a moving image. Namely, when the aforementioned present invention is applied to the case in which a large screen has plural LED power sources, luminance in the screen becomes equal to reduce unevenness of luminance due to variations in the amount of current.

[0107] Also, when the aforementioned present invention is applied to the case in which plural LED drive power sources are provided in a mobile terminal device having a liquid crystal display screen, luminance in the screen becomes equal to reduce unevenness of luminance due to variations in the amount of current. An embodiment in which the liquid crystal display device shown in **FIG. 2** is incorporated into the mobile terminal device will be explained with reference to the drawings.

[0108] As illustrated in **FIG. 7A**, such a mobile terminal device **19** includes a housing **192** and a transparent cover section **192** attached to a portion where a liquid crystal display device is incorporated.

[0109] "2.2-inch QVGA scan backlight stereoscopic LCD" by Akimasa Yuki presented at the 3DC Conference 2005 in NAGOYA describes a scan backlight in which LEDs as light sources are arranged at both left and right sides of one light-guide plate and a double-sided prism sheet is placed on the light-guide plate. In this case, an image signal for a left eye and an image signal for a right eye are supplied to a liquid crystal panel in a time divisional manner. The left LED is lit during the time when the liquid crystal panel displays the image for a left eye and the right LED is lit during the period when the liquid crystal panel displays the image for a right eye. Such control implements stereoscopic image display without using special glasses.

[0110] The following will explain the case in which the present invention is applied to such scan backlight.

[0111] As illustrated in **FIG. 7B**, an LED**1** is placed at the left side of a light-guide plate **181** and an LED**2** is placed at the right side thereof. A reflection plate **182** for preventing light from leaking from the light-guide plate **181** is placed under the light-guide plate **181**. An optical sheet **184** and a double-sided prism sheet **183** are provided between a liquid crystal panel **185** and the light-guide plate **181**. Triangular prisms are formed on a surface of the double-sided prism sheet **183** facing the light-guide plate **181**. A columnar lenticular lens is formed on a surface of the double-sided prism sheet **183** facing the liquid crystal panel **185**. The optical sheet **184** works to supply an emitting light of the double-sided prism sheet **183** to the liquid crystal panel **185** after scattering and concentrating the beam appropriately. In such scan backlight, LED**1** and LED**2** arranged at both left and right sides of the light-guide plate **181** are turned on and off in a time divisional manner. The outputs of the plural LED driving sections **161** and **162** and the drive switching section **163** are connected to LED**1** and LED**2**. The LED drive controlling section **15** is connected to the LED driving section **16**. The LED controlling section **15** supplies the PWM signal to the plural LED driving sections **161** and **162** of the LED driving section **16** and the drive switching section **163** in common respectively. A nonvolatile memory **17** stores an initial value of the PWM value for LED.

[0112] Application of the present invention to such scan backlight makes it possible to equalize emission luminance of LED**1** and LED**2** even if there is a difference in the drive capability between the plurality of LED driving sections **161** and **162**. This equalizes the luminance of a parallax image for a left eye and that of a parallax image for a right eye. This allows a high-definition stereoscopic image display to be implemented in the mobile terminal device.

[0113] As mentioned above, the present invention can be applied to the liquid crystal display device, which uses PWM dimming to switch the output of the driving section one line by one by the driving section, the liquid crystal display device for a large screen, which switches the output of the driving section every plural lines to offer a blinking backlight for a moving image, and the mobile terminal device having plural power sources for driving.

[0114] Although preferred embodiments of the invention have been described with reference to the drawings, it will be obvious to those skilled in the art that various changes or modifications may be made without departing from the true scope of the invention.

1. A lighting device of backlight type that transmits light of a plurality of light emitting elements from a display section, comprising:

a plurality of driving sections that drive the plurality of light emitting elements; and

a drive switching section, provided between the plurality of driving sections and the plurality of light emitting elements, for switching the drive of the plurality of light emitting elements alternately at every fixed cycle.

2. The lighting device according to claim 1, wherein at least one light-off time is provided within one frame time during which one screen is displayed on the display section and the drive of the light emitting elements is switched within the light-off time.

3. The lighting device according to claim 1, wherein the drive switching section controls the switching of the plurality of light emitting elements alternately using a plurality of drive control signals each having a different timing.

4. The lighting device according to claim 3, further comprising switch signal generating section for supplying a switch signal to the drive switching section,

wherein the drive switching section alternately switches the plurality of light emitting elements and the plurality of driving sections respectively to be connected to each other and to adjust an output difference between the plurality of driving sections according to a level change from inactive to active in the drive control signal.

5. The lighting device according to claim 4, wherein the drive switching section comprises a plurality of switches.

6. The lighting device according to claim 1, wherein the plurality of light emitting elements are respectively driven alternately while maintaining a light-on state.

7. The lighting device according to claim 1, wherein the plurality of driving sections drive the plurality of light emitting elements by pulse width modulation (PWM) dimming and the drive switching section switches the drive of the light emitting elements during the light-off time in PWM dimming.

8. A liquid crystal display device comprising:

a liquid crystal display section; and

a lighting device of backlight type that transmits light of a plurality of light emitting elements from the display section, wherein:

a plurality of driving sections that drive the plurality of light emitting elements; and

a drive switching section, provided between the plurality of driving sections and the plurality of light emitting elements, for switching the drive of the plurality of light emitting elements alternately at every fixed cycle are included.

9. The liquid crystal display device according to claim 8, wherein the drive switching section of the lighting device controls the switching of the plurality of light emitting elements alternately by use of a plurality of drive control signals each having a different timing.

10. The liquid crystal display device according to claim 9, further comprising:

a switch signal generating section for supplying a switch signal to the drive switching section of the lighting device,

wherein the drive switching section alternately switches the plurality of light emitting elements and the plurality of driving sections respectively to be connected to each other and to adjust an output difference between the plurality of driving sections according to a level change from inactive to active in the drive control signal.

11. A mobile terminal device comprising:

a liquid crystal display section; and

a lighting device of backlight type that transmits light of a plurality of light emitting elements from a display section, wherein:

a plurality of driving sections that drive the plurality of light emitting elements; and

a drive switching section, provided between the plurality of driving sections and the plurality of light emitting elements, for switching the drive of the plurality of light emitting elements alternately at every fixed cycle are included.

12. The mobile terminal device according to claim 11, wherein the drive switching section of the lighting device controls the switching of the plurality of light emitting elements alternately by use of a plurality of drive control signals each having a different timing.

13. The mobile terminal device according to claim 12, further comprising:

a switch signal generating section for supplying a switch signal to the drive switching section of the lighting device,

wherein the drive switching section alternately switches the plurality of light emitting elements and the plurality of driving sections respectively to be connected to each other and to adjust an output difference between the plurality of driving sections according to a level change from inactive to active in the drive control signal.

14. The mobile terminal device according to claim 13, wherein the drive switching section of the lighting device is a plurality of switches and the switch signal generating section of the lighting device is a switch signal generating section.

15. A method for controlling a lighting device of backlight type that transmits light of a plurality of light emitting elements from a back surface of a display section,

wherein the lighting device comprises a plurality of driving sections that drive the plurality of light emitting elements, a plurality of current switching sections provided between the plurality of driving sections and the plurality of light emitting elements, and a switch signal generating section that supplies a switch signal to the current switching section,

the method comprising the steps of:

alternately switching the plurality of light emitting elements and the plurality of driving sections respectively to be connected to each other by each of the plurality of current switching section according to a level change from inactive to active in the drive control signal; and

causing a sense section to detect light of the light emitting elements lit alternately according to the switching and connection to control the switching of emission of the light emitting elements based on the detection result by the current switching section.

16. The method for controlling the lighting device according to claim 15, further comprising the step of switching the drive of the light emitting elements by the current switching section at a predetermined fixed cycle and within light-off time.

17. The method for controlling the lighting device according to claim 15, further comprising the step of adjusting an output difference between the driving sections of the light emitting elements by switching the light emitting elements alternately according to a switch signal of the plurality of current switching sections each having a different timing.

18. The method for controlling the lighting device according to claim 15, further comprising the luminance unevenness reduction step of adjusting an output difference between the plurality of driving sections by alternately switching the plurality of light emitting elements and the plurality of driving sections to be connected to each other according to a level change from inactive to active in the drive control signal.

19. The method for controlling the lighting device according to claim 15, further comprising the step of adjusting an output difference between the plurality of driving sections by alternately switching the plurality of current switching sections to be connected to the light emitting elements by the plurality of driving sections according to a level change from inactive to active in the drive control signal.

20. The method for controlling the lighting device according to claim 15, further comprising the step of alternately driving each of the plurality of light emitting elements by at least two or more driving sections according to a level change from inactive to active in the drive control signal.

21. The method for controlling the lighting device according to claim 15, further comprising the step of alternately driving each of the plurality of light emitting elements by the driving sections while maintaining a lighting state according to a level change from inactive to active in the drive control signal.

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