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Remarks:

The application is published incomplete as filed (Rule 68(1) EPC).

(54) **Improved display**

(57) It is disclosed a display device (10) comprising a control unit (16) and a plurality of pixel units (20), each pixel unit comprising: input means for receiving a driving voltage transmitted by said control unit (16), a first memory element (22) operatively connected to said input means for storing a driving voltage value, a regulating unit (21, 31) operatively connected to said first memory element (22) for regulating a light in function of a driving

voltage value stored by said first memory element (22). Input means comprises a second memory element (23) for storing a second driving voltage value and first switching means (24) for transferring said second driving voltage value to said first voltage value. The control unit (16) is adapted to control simultaneously the first switching means of said plurality of pixel units, so as to transfer simultaneously for each pixel unit of said plurality said second driving voltage to said second memory element.

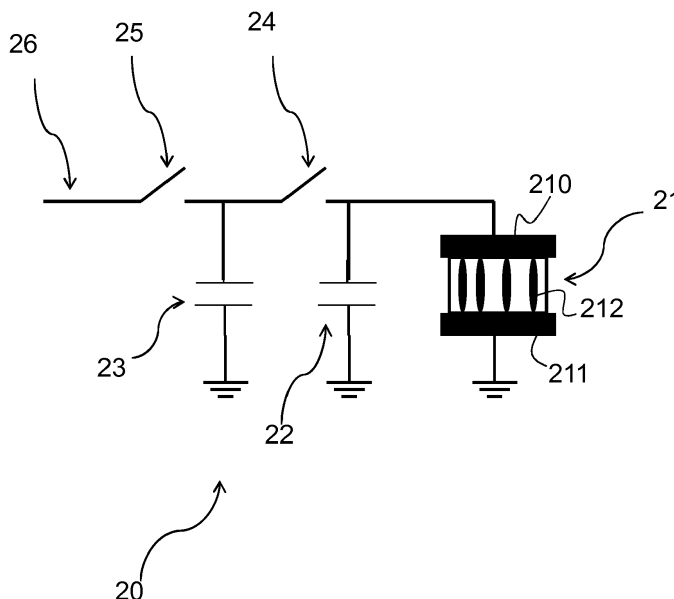


Figure 3

Description

TECHNICAL FIELD

[0001] The present invention relates to the field of multimedia systems, and in particular to electronic visual displays. More particularly, the invention relates to an electronic display according to the preamble of claim 1.

BACKGROUND ART

[0002] In recent years electronic display market has grown more and more, in particular the flat TV segment.

[0003] Nowadays, flat displays have a pixel matrix structure wherein each pixel comprises at least three sub-pixels, one for each colour of the RGB colour model, i.e. red, green and blue. Colour images are displayed by driving properly all sub-pixels of the matrix.

[0004] Sub-pixels can be based on several technologies, such as liquid crystal display (LCD), plasma, organic led (OLED)...

[0005] For example, a LCD pixel typically consists of a layer of liquid crystal molecules aligned between two transparent electrodes, and two polarizing filters, the axes of transmission of which are perpendicular to each other. The LCD pixel is back-lighted by a source of white light. The surface of the electrodes that are in contact with the liquid crystal material are treated so as to align the liquid crystal molecules in a particular direction. Electrodes are made of a transparent conductor called Indium Tin Oxide (ITO).

[0006] Before applying an electric field, the orientation of the liquid crystal molecules is determined by the alignment at the surfaces of electrodes. In a twisted nematic LCD pixel, the surface alignment directions at the two electrodes are perpendicular to each other and coincident with polarization direction of respective polarizing filters, and so the molecules arrange themselves in a helical structure, or twist. This causes the rotation of the polarization of the incident light that is transmitted through the liquid crystal and the pixel appears luminous. If the applied voltage is large enough, the liquid crystal molecules in the centre of the layer are almost completely untwisted and the polarization of the incident light is not rotated as it passes through the liquid crystal layer. This light will then be mainly polarized perpendicular to the second filter, and thus be blocked and the pixel will appear black. By controlling the voltage applied across the liquid crystal layer in each pixel, light can be allowed to pass through in varying amounts thus constituting different levels of luminosity. If a colour filter is applied, the pixel is a colour pixel.

[0007] In simple and small monochrome displays, each row or column of the display has a single electrical circuit. The pixels are addressed one at a time by row and column addresses. This type of display is called passive-matrix addressed because the pixel must retain its state between refreshes without the benefit of a steady

electrical charge. As the number of pixels increases, passive matrix display shows several problems, such as poor contrast. High-resolution colour displays use an active matrix structure. A matrix of thin-film transistors (TFTs) is added to the polarizing and colour filters. Each pixel has its own dedicated transistor, allowing each column line to access one pixel. Each pixel has a capacitor that is used to maintain the state of the pixel until the next refresh cycle. When a row line is activated, all of the column lines are connected to a row of pixels and the correct voltage is driven onto all of the column lines. The row line is then deactivated and the next row line is activated. All of the row lines are activated in sequence during a refresh operation. Active-matrix displays appear brighter and sharper than passive-matrix displays of the same size.

[0008] An important technical feature of a display is response time, i.e. the time needed to control all the pixels so as to display a video frame.

[0009] Estimation for the response time of a passive matrix display may consist in the response time of the single pixel multiplied by the total number of pixels. In a similar way, the estimation for the response time of an active matrix display may consist in the response time of the single row multiplied by the total number of rows. Since pixels of a row are driven in parallel, the response time of a row can be comparable to the response time of a single pixel, as a consequence the active matrix displays have reduced response times compared to the passive ones.

[0010] High response time causes the well-known motion blur effect and so results in a poor image quality.

[0011] Particular applications, e.g. videogames, require very short response times that can be obtained only through active matrix display using very expensive technologies. Moreover, even the known best display may show blur effect to extremely sensitive viewers.

OBJECTS AND SUMMARY OF THE INVENTION

[0012] It is an object of the present invention to overcome the drawbacks of the prior art.

[0013] In particular, it is an object of the present invention to present a display device which is alternative to the prior art.

[0014] It is an object of the present invention to provide a display device with very short response time.

[0015] According to the invention these and other objects are achieved by means of a method comprising the features of the annexed claims, which are an integral part of the present description.

[0016] According to one aspect of the invention, a display device comprises a control unit and a plurality of pixel units. Each pixel unit comprises input means for receiving a driving voltage transmitted by the control unit, and a first memory element (e.g. a capacitor) for storing a driving voltage value. Each pixel unit also comprises a regulating unit for regulating a light in function of the driving voltage stored by the first memory element. The

input means comprises a second memory element for storing a second driving voltage value and switching means for transferring said second driving voltage value to said first voltage value. The control unit is adapted to control simultaneously the switching means of said plurality of pixel units so as to transfer at the same time the second driving voltage to the second memory element for each pixel unit.

[0017] The use of two memory elements opportunely connected and controlled, allows preloading of the pixel values of a frame in a matrix of memory elements that can be simultaneously operated to transfer their content to the active portion of the pixel, e.g. an LCD cell that modulates the light of a backlighting source or a LED cell that generates a coloured light.

[0018] This solution therefore reduces the response time of the display device since all the pixels are refreshed simultaneously, while pixel values of the next frame are loaded in the additional memory area during display of the current frame.

[0019] In another aspect of the invention, the control unit is adapted to transmit the driving voltage over a pixel input line. The input means of each pixel unit comprises second switching means for connection of the second memory element to the pixel input line. The pixel units form a pixel matrix and the control unit is adapted to control the second switching means row by row. This solution offer the advantage that the second memory elements dedicated to store a frame to be displayed, are loaded row by row, thereby in a fast way. N this way control of the switches is simplified since it is possible to consider time guard intervals when opening and closing the switching means for transferring data from the second to the first memory element, or for charging data in the second memory element.

[0020] According to another aspect, the first memory element comprises a first capacitor and the second memory element comprises a second capacitor. The first switching element is adapted to connect said first and second capacitor in parallel.

[0021] In this way, by closing a switch a driving voltage value (i.e. the charge stored by the capacitor) is transferred from one capacitor to the other. Since the capacitors are in parallel, the charge distributes on the two capacitors. Although this solution does not allow a full transfer of the value stored by the first second element to the first one, this solution is very cheap.

[0022] In one embodiment, the capacity of the second capacitor is at least ten times greater than the capacity of the first capacitor, therefore the voltage drop across the first capacitor will be very close to that across the second capacitor. In this way a cheap and efficient solution is obtained.

[0023] Further objects and advantages of the present invention will be clear from the following description of a preferred embodiment disclosed as non limitative and exemplificative example.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The invention will be presented here below with reference to non limiting examples, provided for explicative and non limitative reasons in the annexed drawings. These drawings illustrate different aspects and embodiments of the present invention and, where appropriate, reference numerals illustrating like structures, components, materials and/or elements in different figures are indicated by similar reference numbers.

Figure 1 illustrates a display device according to the present invention.

Figure 2 illustrates an exploded view of certain components of the display device of figure 1.

Figure 3 shows a pixel structure according to a first embodiment of the present invention.

Figure 4 shows a pixel structure according to a second embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0025] While the invention is susceptible of various modifications and alternative constructions, certain illustrated embodiments thereof have been shown in the drawings and will be described below in detail. It should be understood, however, that there is no intention to limit the invention to the specific form disclosed, but, on the contrary, the invention is to cover all modifications, alternative constructions, and equivalents falling within the spirit and scope of the invention as defined in the claims.

[0026] In the following description the use of "e.g.," "etc.," and "or" indicates non-exclusive alternatives without limitation unless otherwise noted. The use of "including" means "including, but not limited to," unless otherwise noted. Similarly, "comprising" means "comprising, but not limited to,".

[0027] The expression "transferring" of a signal or of a physical quantity shall be interpreter in broad sense, and shall comprise also the case in which losses are present due to the transferring process.

[0028] Figures 1 and 2 shows an electronic flat display, in particular a TV set 10, and some of its components.

[0029] TV set 10 comprises an LCD panel 11, a back-light white fluorescent lamp 12, a power supply unit 13, an electric plug 14, a TV tuner 15, a control unit 16, an antenna input 17, a screen 18 and a case 19.

[0030] TV set 10 is provided with an electric plug 14 for connection to an electrical grid, in particular a domestic grid providing AC voltage, e.g. 230V @ 50Hz. Power supply unit 13 converts the alternating voltage into a direct voltage useful to supply other components of the TV set 10, like the control unit 16, the fluorescent lamp 12 and the TV tuner 15.

[0031] TV set 10 receives TV signals from an antenna that is connected to input means 17 (e.g. a cable connector). TV tuner 15 receives the signals, decodes them and transmits them to the control unit 16.

[0032] Control unit 16 comprises a display driver for driving lamp 12 and the LCD panel 11.

[0033] In the preferred embodiment described with reference to figures 1 and 2, LCD panel 11 comprises a pixel active matrix having dimension of 1920x1020 pixels, also known as Full HD resolution. In alternative embodiments LCD panel 11 can have different resolution, i.e. different number of pixels. Control unit 16 controls lamp 12 and LCD panel 11 so as to regulate (and in particular to modulate) the light of the lamp 12 so that light passing through the pixel cell has the expected colour and intensity according to the video component of received TV signal.

[0034] Each pixel is preferably composed of three or four sub-pixels for the different colours.

[0035] Control unit 16 drives, directly or indirectly, each sub-pixel 20 of the pixel matrix in order to display the frames of the audio-video stream in a proper sequence.

[0036] In particular each LCD sub-pixel 20 comprises a LCD cell made of two polarizing electrodes 210 and 211 containing the liquid crystal 212, whose light transmittance changes in function a driving voltage applied between the two electrodes. For example, if the driving voltage applied is near to 0 V, the pixel transmittance is maximum, e.g. it is near 50%, and the pixel is white. Whereas, if the driving voltage is greater than a predetermined threshold the pixel transmittance is minimum, i.e. near to 0%, and the pixel is black. With voltage between 0V and the predetermined threshold, the pixel takes a colour which depends on the colour filters applied to the pixel cell and on the amplitude of the driving voltage.

[0037] Figure 3 shows a structure of a pixel unit, in particular of a LCD sub-pixel 20 according to an embodiment of the invention. LCD sub-pixel 20 comprises an active portion and an input portion. The active portion comprises a LCD cell 21 and a first capacitor 22 connected in parallel with the LCD cell 21, in particular between the two polarizing electrodes of the cell. The input portion comprises input means for receiving the driving voltage for driving the LCD cell. The input portion comprises a second capacitor 23, a first switch 24 connected between the capacitors 22 and 23 and a second switch 25.

[0038] The capacity of the second capacitor 23 is bigger, preferably it is ten times greater, than capacity of the first capacitor 22.

[0039] A first electrode 211 of LCD cell 21 is connected to ground, as well as a first terminal of the first capacitor 22, whereas a second electrode 210 of LCD cell 21 and a second terminal of the first capacitor 22 are connected together so that LCD cell 21 and the first capacitor 22 are connected in parallel. Capacitor 22 is used to maintain the driving voltage of the LCD cell 21 until a next refresh cycle thanks to well known capacitor property to store electric charges. Capacitor 22 is therefore in charge of driving the LCD cell 21 with a driving voltage which generates the desired colour of the sub-pixel according to the video frame currently displayed by the TV set.

[0040] Capacitor 23 has a first terminal connected to ground and a second terminal connectable to the second terminal of capacitor 22 via switch 24. In one embodiment switch 24 can be a transmission gate comprising a N-MOSFET transistor and a P-MOSFET transistor in parallel.

[0041] When switch 24 is closed the two capacitors 22 and 23 are therefore connected in parallel, whereas when the switch 24 is open the two capacitors 22 and 23 are isolated from each other.

[0042] Switch 25 (e.g. a CMOS transmission gate) is connected between the second terminal of capacitor 23 and an input pixel line 26 that is operatively connected to the control unit 16.

[0043] In a preferred embodiment, the switches 24 and 25 and the capacitors 22 and 23 are produced by thin film technology.

[0044] In operation, let assume that at time to display device is displaying frame i of a received video signal. At time t0, switch 24 is open and capacitor 22 holds a charge and drives LCD cell 21 so that light passing through the cells assumes a colour associated to the voltage drop across capacitor 22.

[0045] Meanwhile frame i is displayed and switch 24 is open, control unit 16 closes switch 25 and connect capacitor 23 to the input line 26. Control unit 16 drives, directly or indirectly by means of other devices (e.g. a driver or an amplifier), input line 26 so as to refresh voltage drop across capacitor 23.

[0046] In particular, after opening switch 24 and closing switch 25, control unit 16 applies capacitor 23 a voltage corresponding to the driving voltage that shall be applied to LCD cell 21 at time t1 (following t0) wherein frame i+1 shall be displayed.

[0047] At time t1, control unit opens switch 25 and closes switch 24. In this way the charge hold by capacitor 23 is distributed between capacitor 23, capacitor 22 and LCD cell 21. Since capacitor 23 is bigger than capacitor 22, and considering LCD cell as a "resistive" element, voltage drop across capacitor 22 becomes almost equal to the voltage provided by control unit to capacitor 23 at time t0. At time t1 LCD cell 21 is driven by a new driving voltage equal to the voltage set by control unit at time t0 upon capacitor 23, i.e. the driving voltage requested by frame i+1 for sub-pixel 20.

[0048] After the process of charge transmission between the two capacitors 22 and 23 has been completed, the first switch 24 is opened again and switch 25 is closed so as to refresh the value of voltage drop across capacitor 23 with the driving voltage requested for sub-pixel by frame i+2.

[0049] Each pixel of the pixel matrix of the TV set has the structure described above. Control unit 16 drives all switches 24 of the LCD panel with the same control signal simultaneously so that all pixels refresh of the respective capacitors 22 in the same time. As a consequence, the whole frame is displayed in the same time instant.

[0050] On the contrary, the control unit 16 accomplish-

es the refresh of the capacitors 23 row by row, using well known active matrix addressing schemes; an example of such addressing scheme is disclosed by US patent application US4917467A. In the preferred embodiment, refresh of capacitors 23 for the entire pixel matrix is completed in the time period between displaying of two consecutive frames; for example if the frame rate is equal to 25 frame per second, the second capacitor refresh process has to last less, preferably much less, than 40 ms. This is obtained by opportunely dimensioning the driver driving line 26 and by selecting opportunely the capacity of capacitor 23. Alternatively, control unit 16 may use any other well known addressing methods to refresh capacitors 25.

[0051] In a second embodiment described with reference to figure 4, a sub-pixel 200 comprises an organic light emitting diode cell 31 (OLED cell) in place of LCD cell of sub-pixel 20 above described. Differently from LCD cells, which act as modulators of a source of light emitted by lamp 12, OLED cells generates a light autonomously, lamp 12 is therefore not necessary in this embodiment. Different OLEDs are selected depending of the colours they are expected to emit. Intensity and colour is then controlled by a driving voltage as per the LCD cells. For this reason, the circuits controlling colour of the pixels are very similar and are hereby described using the same reference number of figure 3 where possible.

[0052] Capacitor 22 and OLED cell 31 are connected in parallel so that the voltage drop across capacitor 22 drives the OLED cell 31.

[0053] OLED cell 31 comprises an active transconductance amplifier 310 connected to the anode of an organic light emitting diode 311 (OLED) having the cathode connected to ground.

[0054] In the embodiment of figure 4, amplifier 310 is a P-MOSFET transistor in common source configuration, with the gate coincident with the amplifier input terminal, the drain coincident with the amplifier output terminal (i.e. the terminal connected to the OLED) and the source connected to a reference potential V_{ref} .

[0055] Amplifier 310 reads the voltage at its input terminal (the gate of the p-MOSFET) and generates a current driving the OLED 311. According to the physical law of OLEDs, the OLED luminous flux intensity is roughly proportional to electric current flowing in it. As a consequence, sub-pixel 200 assumes a specific colour level according to driving voltage stored by the first capacitor 22.

[0056] Controls of switches 24 and 25 for charging capacitors 22 and 23 is the same as discussed above with reference to figure 3 and therefore is not repeated here.

[0057] It is clear that the man skilled in the art may apply several modification to the system described above without departing from the scope of the present invention as defined by claims.

[0058] As an example, in an alternative embodiment, OLED 311 may be a common light emitting diode (LED) or, more in general, any device suitable to regulate a light

source or to generate a light based on a driving electrical signal.

[0059] Although the invention has been particularly described with reference to sub-pixels units 20, the invention can be applied to monochromatic display devices or to other display devices wherein light emitted by a pixel unit, i.e. a pixel, sub-pixel or combination of them.

[0060] Switches 24 and 25 may be any type of switches different from transmission gates, e.g. they can be single transistor switches.

[0061] The first capacitor 22 and the second capacitor 23 may have different capacity values, even if it is convenient that capacity of capacitor 23 is much greater than the capacity of the capacitor 22.

[0062] In general, capacitors 22 and 23 are memory elements adapt for storing an electrical signal for the time needed to accomplished refresh processes. These elements can therefore be replaced by any other type of memory.

[0063] Moreover, other configurations of capacitors 22 and 23 can be used in order to obtain the same result of reducing response time of the display device.

Claims

1. Display device (10) comprising a control unit (16) and a plurality of pixel units (20), each pixel unit comprising:

input means for receiving a driving voltage transmitted by said control unit (16),
a first memory element (22) operatively connected to said input means for storing a driving voltage value,
a regulating unit (21, 31) operatively connected to said first memory element (22) for regulating a light in function of a driving voltage value stored by said first memory element (22),
characterized in that said input means comprises
a second memory element (23) for storing a second driving voltage value and,
first switching means (24) for transferring said second driving voltage value to said first voltage value,
whereby said control unit (16) is adapted to control simultaneously the first switching means of said plurality of pixel units, so as to transfer simultaneously for each pixel unit of said plurality said second driving voltage to said second memory element.

2. Display device (10) according to claim 1, wherein said control unit (16) is adapted to transmit said driving voltage over a pixel input line (26), wherein said input means comprises second switching means (25) for connection of said second memory element

(22) to said pixel input line (26), wherein said plurality of pixel units (20) forms a pixel matrix, and wherein said control unit (16) is adapted to control said second switching means (25) row by row.

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4. Display device according to any claim 1-3, wherein said first memory element (22) comprises a first capacitor and said second memory element (23) comprises a second capacitor, and wherein said first switching element is adapted to connect said first and second capacitor in parallel.

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5. Display device according to claim 4, wherein the capacity of said second capacitor is at least ten times greater than the capacity of said first capacitor.

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6. Display device according to any of claims 4 or 5, wherein said first and second capacitor and said first switching means are produced by thin film technology.

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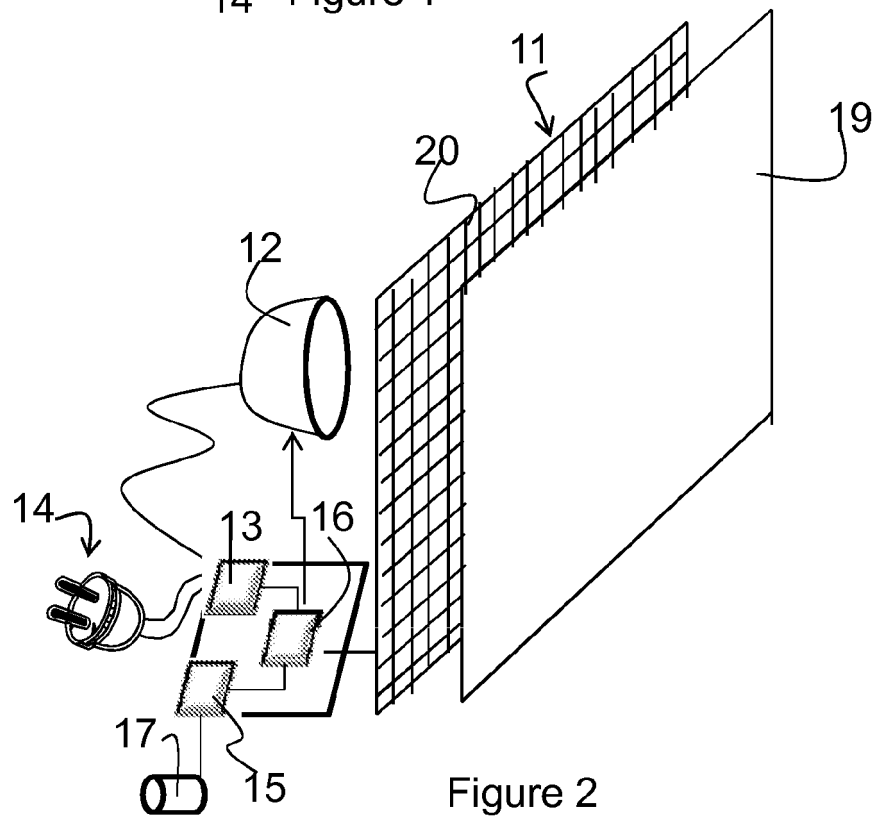
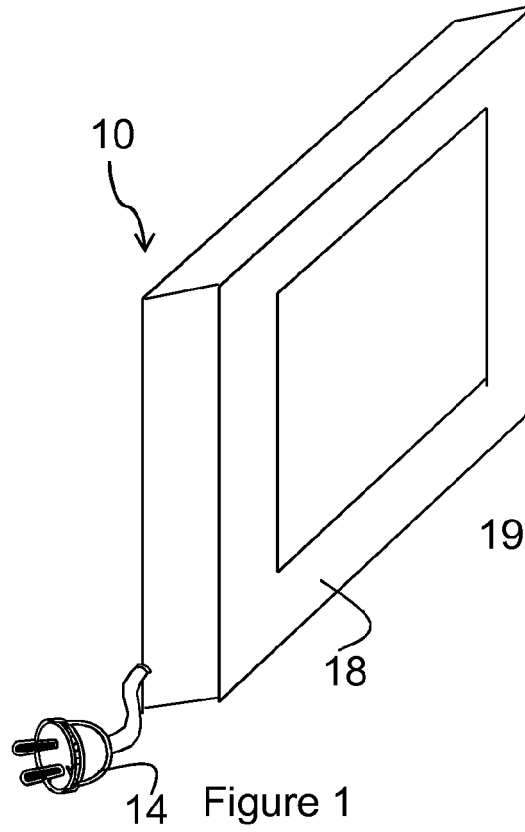
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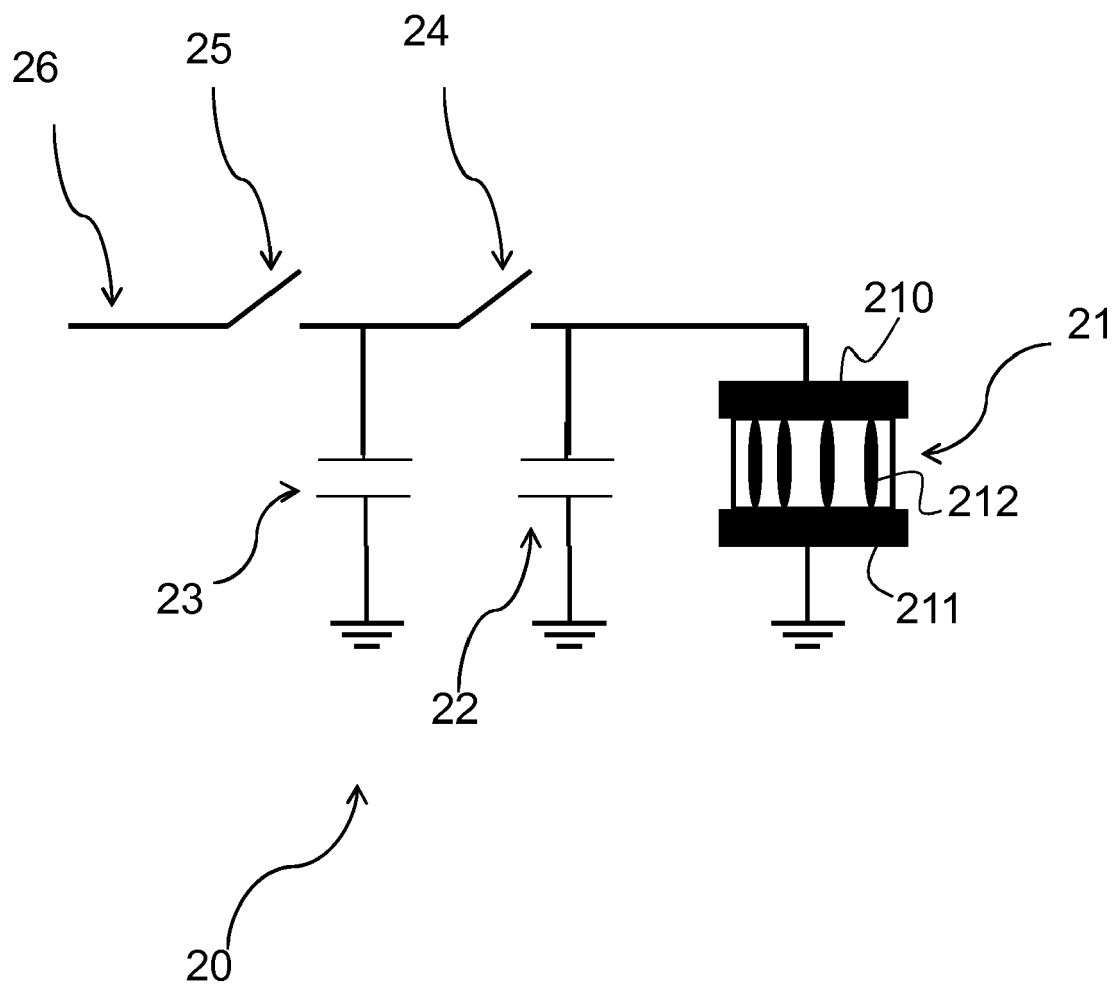


Figure 3

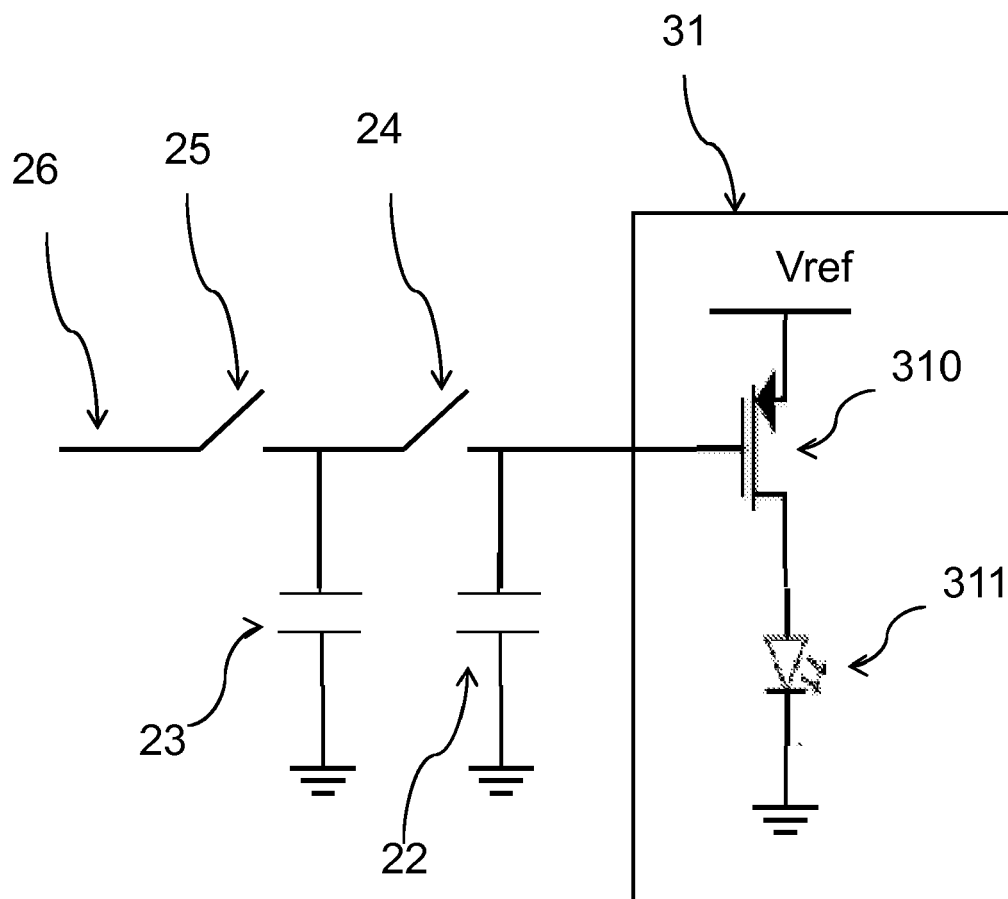


Figure 4



EUROPEAN SEARCH REPORT

Application Number
EP 10 19 7439

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 6 181 311 B1 (HASHIMOTO SEIJI [JP]) 30 January 2001 (2001-01-30)	1,2,4,6	INV. G09G3/36
Y	* column 1, line 8 - column 2, line 4 * * column 4, line 41 - column 6, line 65; figures 1-4 *	5	G09G3/32

X	US 2003/122756 A1 (KIM YOUNG-SUN [KR] ET AL) 3 July 2003 (2003-07-03)	1,2,4	
Y	* paragraph [0020] - paragraph [0038]; figures 2, 4A-4H *	5	

X	EP 1 724 752 A2 (HARVATEK CORP [TW]) 22 November 2006 (2006-11-22)	1,2,4	
	* paragraph [0013] - paragraph [0019]; figures 3-5 *		

The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 11 April 2011	Examiner Harke, Michael
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 10 19 7439

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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11-04-2011

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Patent documents cited in the description

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