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(54) ELECTROLUMINESCENT DISPLAY INITIAL NON-UNIFORMITY-COMPENSATED DRIVE SIGNAL

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to control of an analog signal applied to a drive transistor for supplying current through an electroluminescent emitter.

BACKGROUND OF THE INVENTION

[0002] Flat-panel displays are of great interest as information displays for computing, entertainment, and communications. For example, electroluminescent (EL) emitters have been known for some years and have recently been used in commercial display devices. Such displays employ both active-matrix and passive-matrix control schemes and can employ a plurality of subpixels. Each subpixel contains an EL emitter and a drive transistor for driving current through the EL emitter. The subpixels are typically arranged in two-dimensional arrays with a row and a column address for each subpixel, and having a data value associated with the subpixel. Subpixels of different colors, such as red, green, blue, and white are grouped to form pixels. EL displays can be made from various emitter technologies, including coatable-inorganic light-emitting diode, quantum-dot, and organic light-emitting diode (OLED).

[0003] Electroluminescent (EL) flat-panel display technologies, such as organic light-emitting diode (OLED) technology provides benefits in color gamut, luminance, and power consumption over other technologies such as liquid-crystal display (LCD) and plasma display panel (PDP). However, such displays suffer from a variety of defects that limit the quality of the displays. In particular, OLED displays suffer from visible nonuniformities across a display. These nonuniformities can be attributed to both the EL emitters in the display and, for active-matrix displays, to variability in the thin-film transistors used to drive the EL emitters.

[0004] Some transistor technologies, such as low-temperature polysilicon (LTPS), can produce drive transistors that have varying mobilities and threshold voltages across the surface of a display (Yue Kuo, ed. "Thin Film Transistors: Materials and Processes, Vol. 2, Polycrystalline Thin Film Transistors." Boston: Kluwer Academic Publishers, 2004. Pg. 412). This produces objectionable nonuniformity. Further, nonuniform OLED material deposition can produce emitters with varying efficiencies, also causing objectionable nonuniformity. These nonuniformities are present at the time the panel is sold to an end user, and so are termed initial nonuniformities, or "mura." FIG. 9 shows an example histogram of subpixel luminance exhibiting differences in characteristics between subpixels. All subpixels were driven at the same level, so should have had the same luminance. As FIG. 9 shows, the resulting luminances varied by 20 percent in either direction. This results in unacceptable display performance.

[0005] It is known in the prior art to measure the performance of each pixel in a display and then to correct for the performance of the pixel to provide a more uniform output across the display.

[0006] US Patent Application No. 2003/0122813 by Ishizuki et al. discloses a display panel driving device and driving method for providing high-quality images without irregular luminance. The light-emission drive current flowing is measured while each pixel successively and independently emits light. Then the luminance is corrected for each input pixel data based on the measured drive current values. According to another aspect, the drive voltage is adjusted such that one drive current value becomes equal to a predetermined reference current. In a further aspect, the current is measured while an off-set current, corresponding to a leak current of the display panel, is added to the current output from the drive voltage generator circuit, and the resultant current is supplied to each of the pixel portions. The measurement techniques are iterative, and therefore slow. Further, this technique is directed at compensation for aging, not for initial nonuniformity.

[0007] US Patent No. 6,081,073 by Salam describes a display matrix with a process and control means for reducing brightness variations in the pixels. This patent describes the use of a linear scaling method for each pixel based on a ratio between the brightness of the weakest pixel in the display and the brightness of each pixel. However, this approach will lead to an overall reduction in the dynamic range and brightness of the display and a reduction and variation in the bit depth at which the pixels can be operated.

[0008] US Patent No. 6,473,065 by Fan describes methods of improving the display uniformity of an OLED. The display characteristics of all organic-light-emitting-elements are measured, and calibration parameters for each organic-light-emitting-element are obtained from the measured display characteristics of the corresponding organic-light-emitting-element. The calibration parameters of each organic-light-emitting-element are stored in a calibration memory. The technique uses a combination of look-up tables and calculation circuitry to implement uniformity correction. However, the described approaches require either a lookup table providing a complete characterization for each pixel, or extensive computational circuitry within a device controller. This is likely to be expensive and impractical in most applications.

[0009] US Patent No. 7,345,660 by Mizukoshi et al. describes an EL display having stored correction offsets and gains for each subpixel, and having a measurement circuit for measuring the current of each subpixel. Although this apparatus can correct for initial nonuniformity, it uses a sense resistor to measure current, and thus has limited signal-to-noise performance. Furthermore, the measurements required by this method can be very time-consuming for large panels.

[0010] US Patent No. 6,414,661 by Shen et al. describes a method and associated system that compensates for long-term variations in the light-emitting efficiency of individual organic light emitting diodes in an OLED display device by calculating and predicting the decay in light output efficiency of each pixel based on the accumulated drive current applied to the pixel and derives a correction coefficient that is applied to the next drive current for each pixel. This patent describes the use of a camera to acquire images of a plurality of equal-sized sub-areas. Such a process is time-consuming and requires mechanical fixtures to acquire the plurality of subarea images.

[0011] US Patent Application No. 2005/0007392 by Kasai et al. describes an electro-optical device that stabilizes display quality by performing correction processing corresponding to a plurality of disturbance factors. A grayscale characteristic generating unit produces conversion data having grayscale characteristics obtained by changing the grayscale characteristics of display data that defines the grayscales of pixels with reference to a conversion table whose description contents include correction factors. However, their method requires a large number of LUTs, not all of which are in use at any given time, to perform processing and does not describe a method for populating those LUTs.

US Patent No. 6,989,636 by Cok et al. describes using a global and a local correction factor to compensate for nonuniformity. However, this method assumes a linear input and is consequently difficult to integrate with image-processing paths having nonlinear outputs.

US Patent No. 6,897,842 by Gu describes using a pulse width modulation (PWM) mechanism to controllably drive a display (e.g., a plurality of display elements forming an array of display elements). A non-uniform pulse interval clock is generated from a uniform pulse interval clock, and then used to modulate the width, and optionally the amplitude, of a drive signal to controllably drive one or more display elements of an array of display elements. A gamma correction is provided jointly with a compensation for initial nonuniformity. However, this technique is only applicable to passive-matrix displays, not to the higher-performance active-matrix displays which are commonly employed.

PCT Patent Application Publication No. WO 2005/101360 A1 discloses an organic EL display apparatus having the display pixels arranged in a matrix form, including in each display pixel an organic EL element. A drive transistor supplies a drive current that depends on brightness data. The display includes a correction gain storage unit for storing display pixel positions and a correction gain for correcting the slope of the brightness-data-based drive current of the drive transistors in the display pixels; and a correction unit for correcting pixel-by-pixel brightness data depending on the pixel position using the correction gain stored in the correction gain storage unit into brightness data for the pixel to generate corrected brightness data. Each of the display pixels is displayed by driving its drive transistor in response to the data generated by the correction gain storage unit and the correction unit and supplying the corresponding organic EL element with the drive current.

US Patent Application Publication No. US 2007/0290958 A1 discloses a method for the correction of average luminance or luminance uniformity variations in an active-matrix OLED display, comprising: a) providing an active-matrix OLED display; b) determining at a first time a first offset voltage and a first gain relationship between the voltage and the current passing through one or more light-emitting elements; c) receiving a signal for driving the light-emitting elements after step b), correcting the signal by employing the first offset voltage and gain relationship values to compute a linear correction for the light-emitting elements to form a corrected signal, and driving the display with the corrected signal; d) determining at a time after the first time an updated offset voltage and an updated gain relationship between the voltage and the current passing through the light-emitting elements; and e) receiving a signal for driving the one or more light-emitting elements after step d), correcting the signal by employing the updated offset voltage and gain relationship values to compute a linear correction for the light-emitting elements to form an updated corrected signal, and driving the display with the updated corrected signal.

Document WO 2009/085113 A2, which is prior art according to Article 54(3) EPC, concerns an apparatus for providing an analog drive transistor control signal to the gate electrode of a drive transistor in a drive circuit that applies current to an EL device, the drive circuit including a first supply electrode of the drive transistor and the EL device connected to a second supply electrode of the drive transistor, comprising a measuring circuit for measuring the current passing through the supply electrodes at different times to provide an aging signal representing variations in the characteristics of the drive transistor and EL device caused by operation of the drive transistor and EL device over time; a compensator for changing a linear code value in response to the aging signal to compensate for the variations in the characteristics of the drive transistor and EL device; and a linear source driver for producing the analog drive transistor control signal in response to the changed linear code value.

There is a need, therefore, for a more complete approach for compensating differences between components in electroluminescent displays, and specifically for compensating for initial nonuniformity of such displays.

SUMMARY OF THE INVENTION

[0012] In accordance with the present invention, there is provided, an apparatus for providing analog drive transistor control signals to the gate electrodes of drive transistors in a plurality of electroluminescent (EL) subpixels in an EL panel in accordance with claim 1.

ADVANTAGES

[0013] The present invention provides an effective way of providing the analog drive transistor control signal. It requires only one measurement to perform compensation. It can be applied to any active-matrix backplane. The compensation of the control signal has been simplified by using a look-up table (LUT) to change signals from nonlinear to linear so compensation can be in linear voltage domain. It compensates for initial nonuniformity without requiring complex pixel circuitry or external measurement devices. It does not decrease the aperture ratio of a subpixel. It has no effect on the normal operation of the panel. It can raise yield of good panels by making objectionable initial nonuniformity invisible.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

FIG. 1 is a block diagram of a control system for practicing the present invention;
FIG. 2 is a detailed schematic of the control system shown in FIG. 1;
FIG. 3 is a diagram of an EL panel which can be used in the practice of the present invention;
FIG. 4 is a timing diagram for operating a measurement circuit shown in FIG. 2;
FIG. 5A is a representative I-V characteristic curve of two subpixels, showing differences in characteristics;
FIG. 5B is an example I-V curve measurement of multiple subpixels;
FIG. 5C is a plot of the effectiveness of compensation;
FIG. 6 is a block diagram of the compensator of FIG. 1;
FIG. 7 is a Jones-diagram representation of the effect of a domain-conversion unit and a compensator;
FIG. 8 is a detailed schematic of one embodiment of an EL subpixel and surrounding circuitry according to the present invention; and
FIG. 9 is a histogram of luminances of subpixels exhibiting differences in characteristics.

DETAILED DESCRIPTION OF THE INVENTION

[0015] The present invention compensates for initial nonuniformity of all subpixels on an electroluminescent (EL) panel, e.g. an active-matrix OLED panel. A panel includes a plurality of pixels, each of which includes one or more subpixels. For example, each pixel might include a red, a green, and a blue subpixel. Each subpixel includes an EL emitter, which emits light, and surrounding electronics. A subpixel is the smallest addressable element of a panel.

[0016] The discussion to follow first considers the system as a whole. It then proceeds to the electrical details of a subpixel, followed by the electrical details for measuring one subpixel and the timing for measuring multiple subpixels. It next covers how the compensator uses measurements. Finally, it describes how this system is implemented in one embodiment, e.g. in a consumer product, from the factory to end-of-life.

Overview

[0017] FIG. 1 shows a block diagram of the display system 10 of the present invention. This figure shows data flow for one subpixel; a plurality of subpixels can be processed in this system serially. The nonlinear input signal 11 commands a particular light intensity from an EL emitter in an EL subpixel, which can be one of many on an EL panel. This signal 11 can come from a video decoder, an image processing path, or another signal source, can be digital or analog, and can be nonlinearly- or linearly-coded. For example, the nonlinear input signal can be an sRGB code value or an NTSC luma voltage. Whatever the source and format, the signal is preferentially converted into a digital form and into a linear domain, such as linear voltage, by a converter 12, which will be discussed further in "Cross-domain processing, and bit depth," below. The result of the conversion will be a linear code value, which can represent a commanded drive voltage.

[0018] The compensator 13 takes in the linear code value, which can correspond to the particular light intensity commanded from the EL subpixel. The compensator 13 outputs a changed linear code value that will compensate for the effects of initial nonuniformity to cause the EL subpixel to produce the commanded intensity. The operation of the compensator will be discussed further in "Implementation," below.

[0019] The changed linear code value from the compensator 13 is passed to a linear source driver 14 which can be a digital-to-analog converter. The linear source driver 14 produces an analog drive transistor control signal, which can be a voltage, in response to the changed linear code value. The linear source driver 14 can be a source driver designed to be linear, or a conventional LCD or OLED source driver with its gamma voltages set to produce an approximately linear output. In the latter case, any deviations from linearity will affect the quality of the results. The linear source driver 14 can also be a time-division (digital-drive) source driver, as taught e.g. in commonly-assigned International Publication No. WO 2005/116971 by Kawabe. A digital-drive source driver provides an analog voltage at a predetermined level commanding light output for an amount of time dependent on the output signal from the compensator. A conventional linear source driver, by contrast, provides an analog voltage at a level dependent on the output signal from the compensator for a fixed amount of time (generally the entire frame). A linear source driver can output one or more analog drive transistor control signals simultaneously.

[0020] The analog drive transistor control signal produced by the linear source driver 14 is provided to an EL subpixel 15. This subpixel includes a drive transistor and an EL emitter, as will be discussed in "Display element description," below. When the analog voltage is provided to the gate electrode of the drive transistor, current flows through the drive transistor and EL emitter, causing the EL emitter to emit light. There is generally a linear relationship between current through the EL emitter and luminance of the output emitter, and a nonlinear relationship between voltage applied to the drive transistor and current through the EL emitter. The total amount of light emitted by an EL emitter during a frame can thus be a nonlinear function of the voltage from the linear source driver 14.

[0021] The current flowing through the EL subpixel is measured under specific drive conditions by a current-measurement circuit 16, as will be discussed further in "Data collection," below. The measured current for the EL subpixel provides the compensator with the information it needs to adjust the commanded drive signal. This will be discussed further in "Algorithm," below.

[0022] This system can compensate for variations in drive transistors and EL emitters in an EL panel over the operational lifetime of the EL panel, as will be discussed further in "Sequence of operations," below.

[0023] The present invention can compensate for differences in characteristics and the resulting nonuniformities at any selected time. However, nonuniformities are particularly objectionable to end users seeing a display panel for the first time. The operating life of an EL display is the time from when an end user first sees an image on that display to the time when that display is disposed of. Initial nonuniformity is any nonuniformity present at the beginning of the operating life of a display. The present invention can advantageously correct for initial nonuniformity by taking measurements before the operating life of the EL display begins. Measurements can be taken in the factory as part of production of a display. Measurements can also be taken after the user first activates a device containing an EL display, immediately before showing the first image on that display. This allows the display to present a high-quality image to the end user when he first sees it, so that his first impression of the display will be favorable.

Display element description

[0024] FIG. 8 shows one embodiment of an EL subpixel and surrounding circuitry. EL subpixel 15 includes drive transistor 201, EL emitter 202, and optionally select transistor 36 and storage capacitor 1002. First voltage supply 211 ("PVDD") can be positive, and second voltage supply 206 ("Vcom") can be negative. The EL emitter 202 has a first electrode 207 and a second electrode 208. The drive transistor has a gate electrode 203, a first supply electrode 204 which can be the drain of the drive transistor, and a second supply electrode 205 which can be the source of the drive transistor. An analog drive transistor control signal can be provided to the gate electrode 203, optionally through a select transistor 36, which is activated by row line 34. The analog drive transistor control signal can be stored in storage capacitor 1002. The first supply electrode 204 is electrically connected to a first voltage supply 211. The second supply electrode 205 is electrically connected to the first electrode 207 of the EL emitter 202. The second electrode 208 of the EL emitter is electrically connected to a second voltage supply 206. The power supplies are typically located off the EL panel. Electrical connection can be made through switches, bus lines, conducting transistors, or other devices or structures capable of providing a path for current.

[0025] In one embodiment of the present invention, first supply electrode 204 is electrically connected to first voltage supply 211 through PVDD bus line 1011, second electrode 208 is electrically connected to second voltage supply 206 through sheet cathode 1012, and the gate electrode 203 of drive transistor 201 is driven with the analog drive transistor control signal produced by linear source driver 14.

[0026] FIG. 2 shows the EL subpixel 15 in the context of display system 10, including nonlinear input signal 11, converter 12, compensator 13, and linear source driver 14 as shown in FIG. 1. As described above, the drive transistor 201 has with gate electrode 203, first supply electrode 204 and second supply electrode 205. The EL emitter 202 has first electrode 207 and second electrode 208. The system has voltage supplies 211 and 206.

[0027] Neglecting leakage, the same current passes from first voltage supply 211, through the first supply electrode 204 and the second supply electrode 205 of the drive transistor 201, through the EL emitter electrodes 207 and 208, to the second voltage supply 206. Therefore, current can be measured at any point in this drive current path. The drive current is what causes EL emitter 202 to emit light. Current can be measured off the EL panel at the first voltage supply 211 to reduce the complexity of the EL subpixel.

Data collection

Hardware

[0028] Still referring to FIG. 2, to measure the current of each EL subpixel quickly, accurately, and without relying on any special electronics on the panel, the present invention employs a measuring circuit 16 comprising a current mirror unit 210, a correlated double-sampling (CDS) unit 220, and an analog-to-digital converter (ADC) 230.

[0029] The current mirror unit 210 can be attached to voltage supply 211 or anywhere else in the drive current path. First current mirror 212 supplies drive current to the EL subpixel 15 through switch 200, and produces a mirrored current on its output 213. The mirrored current can be equal to the drive current or a function of the drive current. For example, the mirrored current can be a multiple of the drive current to provide additional measurement-system gain. Second current mirror 214 and bias supply 215 apply a bias current to the first current mirror 212 to reduce the impedance of the first current mirror as seen from the panel, advantageously reducing the time required to take a measurement. This circuit also reduces changes in the current through the EL subpixels being measured due to voltage changes in the current mirror resulting from current draw of the measurement circuit. This advantageously improves signal-to-noise ratio over other current-measurement options, such as a simple sense resistor, which can change voltages at the drive transistor terminals depending on current. Finally, current-to-voltage (I-to-V) converter 216 converts the mirrored current from the first current mirror into a voltage signal for further processing. I-to-V converter 216 can include a transimpedance amplifier or a low-pass filter. For a single EL subpixel, the output of the I-to-V converter can be the status signal for that subpixel. For measurements of multiple subpixels, as will be discussed below, the measurement circuitry can include further circuitry responsive to the voltage signal for producing a status signal. A respective measurement is taken of each subpixel, and a corresponding status signal produced.

[0030] Switch 200, which can be a relay or FET, can selectively, electrically connect the measuring circuit to the drive current flow through the first and second electrodes of the drive transistor 201. During measurement, the switch 200 can electrically connect first voltage supply 211 to first current mirror 212 to allow measurements. During normal operation, the switch 200 can electrically connect first voltage supply 211 directly to first supply electrode 204 rather than to first current mirror 212, thus removing the measuring circuit from the drive current flow. This causes the measurement circuitry to have no effect on normal operation of the panel. It also advantageously allows the measurement circuit's components, such as the transistors in the current mirrors 212 and 214, to be sized only for measurement currents and not for operational currents. As normal operation generally draws much more current than measurement, this allows substantial reduction in the size and cost of the measurement circuit.

[0031] To drive a current for the measurement circuit to measure, compensator 13 can cause the linear source driver 14 to produce one or more test analog drive transistor control signals at a selected time. The measurement circuit 16 can then measure, for each subpixel 15, a current corresponding to each of the one or more test analog drive transistor control signals. The status signal can then include the one or more respective measured currents and the one or more test analog drive transistor control signals that caused them, or be calculated from those currents and voltages as will be described below. The linear source driver 14 can also produce analog drive transistor control signals which deactivate subpixels in a column once that column has been measured, e.g. by causing the drive transistor to enter the cutoff region.

Sampling

[0032] The current mirror unit 210 allows measurement of the current for one EL subpixel. To measure the current for multiple subpixels, in one embodiment the present invention uses correlated double-sampling, with a timing scheme usable with standard OLED source drivers.

[0033] Referring to FIG. 3, an EL panel 30 useful in the present invention has three main components: a source driver 14 driving column lines 32a, 32b, 32c, a gate driver 33 driving row lines 34a, 34b, 34c, and a subpixel matrix 35. In one embodiment of the present invention, the source driver 14 can include one or more linear source drivers 14. The subpixel matrix 35 includes a plurality of EL subpixels 15 in an array of rows and columns. Note that the terms "row" and "column" do not imply any particular orientation of the EL panel. EL subpixel 15, EL emitter 202, drive transistor 201, and select transistor 36 are as shown in FIG. 8. The gate of select transistor 36 is electrically connected to the appropriate row line 34, and of its source and drain electrodes, one is electrically connected to the appropriate column line 32, and one is connected to the gate electrode 203 of the drive transistor 201. Whether the source is connected to the column line or the drive transistor gate electrode does not affect the operation of the select transistor.

[0034] For clarity, voltage supplies 211 and 206, as shown in FIG. 8, are indicated on FIG. 3 where they connect to each subpixel, as the present invention can be employed with a variety of schemes for connecting the supplies with the subpixels.

[0035] In typical operation of this panel, the source driver 14 drives appropriate analog drive transistor control signals on the respective column lines 32a, 32b, and 32c. The gate driver 33 then activates the first row line 34a, causing the appropriate control signals to pass through the select transistors 36 to the gate electrodes 203 of the appropriate drive transistors 201 to cause those transistors to apply current to their attached EL emitters 202. The gate driver 33 then deactivates the first row line 34a, preventing control signals for other rows from corrupting the values passed through the select transistors 36. The source driver 14 drives control signals for the next row on the column lines, and the gate driver 33 activates the next row 34b. This process repeats for all rows. In this way all subpixels on the panel receive appropriate control signals, one row at a time. The row time is the time between activating one row line (e.g. 34a) and activating the next (e.g. 34b). This time is generally constant for all rows.

[0036] According to the present invention, this row stepping is used advantageously to activate only one subpixel at a time, working down a column. Referring to FIG. 3, suppose only column 32a is driven, starting with all subpixels off. Column line 32a will have an analog drive transistor control signal, such as a high voltage, causing subpixels attached thereto to emit light; all other column lines 32b..32c will have a control signal, such as a low voltage, causing subpixels attached thereto not to emit light. Those control signals can be produced by linear source driver 14. Since all subpixels are off, the panel is drawing a dark current, which can be zero or only a leakage amount. As rows are activated, the subpixels attached to column 32a turn on, and so the total current drawn by the panel rises.

[0037] Referring now to FIG. 4, and also to FIGS. 2 and 3, measurement 49 is taken of the dark current. Then, at time 1, a subpixel is activated (e.g. with row line 34a) and its current 41 measured with measuring circuit 16. Specifically, what is measured is the voltage signal from the current-measurement circuit, which represents the current through the first and second voltage supplies as discussed above; measuring the voltage signal representing current is referred to as "measuring current" for clarity. Current 41 is the sum of the current from the first subpixel and the dark current. At time 2, the next subpixel is activated (e.g. with row line 34b) and current 42 is measured. Current 42 is the sum of the current from the first subpixel, the current from the second subpixel, and the dark current. The difference between the second measurement 42 and the first measurement 41 is the current 43 drawn by the second subpixel. In this way the process proceeds down the first column, measuring the current of each subpixel. The second column is then measured, then the rest of the panel, one column at a time. After a column is measured, all subpixels in that column can be deactivated before the next column is measured. This can be done by stepping down rows deactivating one subpixel at a time. Note that while measuring down a column, each measurement (e.g. 41, 42) is taken as soon after activating a subpixel as possible. In an ideal situation, each measurement can be taken any time before activating the next subpixel, but as will be discussed below, taking measurements immediately after activating a subpixel can help remove error due to self-heating effects. This method allows measurements to be taken as fast as the settling time of a subpixel will allow.

[0038] Referring back to FIG. 2, and also referring to FIG. 4, correlated double-sampling unit 220 samples the measured currents to produce status signals. In hardware, currents are measured by latching their corresponding voltage signals from current mirror unit 210 into the sample-and-hold units 221 and 222 of FIG. 2. The voltage signals can be those produced by I-to-V converter 216. Differential amplifier 223 takes the differences between successive subpixel measurements. The output of sample-and-hold unit 221 is electrically connected to the positive terminal of differential amplifier 223 and the output of unit 222 is electrically connected to the negative terminal of amplifier 223. For example, when current 41 is measured, the measurement is latched into sample-and-hold unit 221. Then, before current 42 is measured (latched into unit 221), the output of unit 221 is latched into second sample-and-hold unit 222. Current 42 is then measured. This leaves current 41 in unit 222 and current 42 in unit 221. The output of the differential amplifier, the value in unit 221 minus the value in unit 222, is thus (voltage signal representing) current 42 minus (voltage signal representing) current 41, or difference 43. Each current difference, e.g. 43, can be the status signal for a corresponding subpixel. For example, current difference 43 can be the status signal for the subpixel attached to row line 34b and column line 32a. In this way, stepping down the rows and across the columns, measurements can be taken of each subpixel. Measurements can successively be taken at a variety of drive levels (gate voltages or current densities) to form I-V curves for each of the measured subpixels.

Algorithm

[0039] Referring to FIG. 5A, I-V curves 501 and 502 are representative characteristics of a first and a second subpixel, respectively. The I-V curves of the different subpixels differ in slope, and in shift on the gate voltage axis. The shift is due to a difference in V_{th}, in keeping with the MOSFET saturation-region drive transistor equation, $I_d = K(V_{gs} - V_{th})^2$ (Lurch, N. Fundamentals of electronics, 2e. New York: John Wiley & Sons, 1971, pg. 110). The difference in V_{th} is shown as threshold voltage difference 503. The slope difference can be caused by differences in mobility of the drive transistor or in voltage or resistance of the EL emitter.

[0040] At a measurement reference gate voltage 510, the currents produced by the first and second subpixels differ by an amount shown as current difference 504. In practice, curves 501 and 502 are generally linear transforms of each other. This allows an offset and a gain to be used to compensate rather than full stored I-V curves for each subpixel. A reference I-V curve can be selected, e.g. the mean of curves 501 and 502. A gain and an offset can then be computed for each curve with respect to the reference by fitting techniques known in the statistical art. The gain and offset together constitute a status signal for the subpixel, and represent the characteristics of the drive transistor and EL emitter in that EL subpixel. The measurements can be used directly to make status signals, or an average of a number of measurements, an exponentially-weighted moving average of measurements over time, or the result of other smoothing methods which will be obvious to those skilled in the art.

[0041] In general, the current of a subpixel can be higher or lower than that of another subpixel. For example, higher temperatures cause more current to flow, so a lightly-aged subpixel in a hot environment can draw more current than an unaged subpixel in a cold environment. The compensation algorithm of the present invention can handle either case.

[0042] FIG. 5B shows an example of measured I-V curve data. The abscissa is code value (0..255), which corresponds to voltage e.g. through a linear map. The ordinate is normalized current on a 0..1 scale. I-V curves 521 (dash-dot) and 522 (dashed) correspond to two different subpixels on an EL panel, selected to represent extremes of variation on the EL panel. Reference I-V curve 530 (solid) is a reference curve calculated as the mean of the I-V curves of all subpixels on the panel. Compensated I-V curves 531 (dash-dot) and 532 (dashed) are the compensated results for I-V curves 521 and 522, respectively. Both I-V curves closely match the reference after compensation.

[0043] The reference I-V curve can also be calculated as the mean of the I-V curves of the subpixels in a particular region of the panel. Multiple reference I-V curves can be provided for different regions of the panel or for different color channels.

[0044] FIG. 5C shows the effectiveness of compensation. The abscissa is code value (0..255). The ordinate is current delta (0..1) between the reference and the compensated I-V curves. Error curves 541 and 542 correspond to I-V curves 521 and 522 after compensation using a gain and offset. The total error is within approximately +/-1% across the full code value range, indicating a successful compensation. In this example, error curve 541 was calculated with gain = 1.2, offset = 0.013, and error curve 542 with gain = 0.0835, offset = -0.014.

Implementation

[0045] Referring to FIG. 6, there is shown an embodiment of compensator 13. The compensator operates on one subpixel at a time; multiple subpixels can be processed serially. For example, compensation can be performed for each subpixel as its linear code value arrives from a signal source in the conventional left-to-right, top-to-bottom scanning order. Compensation can be performed on multiple pixels simultaneously by paralleling multiple copies of the compensation circuitry or by pipelining the compensator as is known in the art.

[0046] The inputs to compensator 13 are the position of a subpixel 601 and the linear code value of that subpixel (input 602), which can represent a commanded drive voltage. The compensator changes the linear code value (LCV) to produce a changed linear code value (CLCV) for a linear source driver, which can be e.g. a compensated voltage out 603. The position 601 is used to retrieve the status signal for the subpixel from status memory 64. Compensation coefficients are then produced by coefficient generator 61 using the status signal and optionally the position 601. The coefficient generator can be a LUT or a passthrough. The coefficients are an offset and a gain for each subpixel. Status memory 64 and coefficient generator 61 can be implemented together as a single LUT. Multiplier 62 multiplies the LCV by the gain, and adder 63 adds the offset to the multiplied LCV to produce the CLCV (output 603).

[0047] Status memory 64 holds a stored reference status signal measurement of each subpixel taken at a selected time. The status signal measurements can be status signals output by the measuring circuit described in "Data collection," above. Status memory 64 can store the reference status signals in nonvolatile RAM, such as a Flash memory, ROM, such as EEPROM, or NVRAM.

Cross-domain processing, and bit depth

[0048] Image-processing paths known in the art typically produce nonlinear code values (NLCVs), that is, digital values having a nonlinear relationship to luminance (Giorgianni & Madden. Digital Color Management: encoding solutions. Reading, Mass.: Addison-Wesley, 1998. Ch. 13, pp. 283-295). Using nonlinear outputs matches the input domain of a typical source driver, and matches the code value precision range to the human eye's precision range. However, compensation is a voltage-domain operation, and thus is preferably implemented in a linear-voltage space. A linear source driver can be used, and domain conversion performed before the source driver, to effectively integrate a nonlinear-domain image-processing path with a linear-domain compensator. Note that this discussion is in terms of digital processing, but analogous processing can be performed in an analog or mixed digital/analog system. Note also that the compensator can operate in linear spaces other than voltage. For example, the compensator can operate in a linear current space.

[0049] Referring to FIG. 7, there is shown a Jones-diagram representation of the effect of a domain-conversion unit 12, in Quadrant I 127, and a compensator 13, in Quadrant II 137. This figure shows the mathematical effect of these units, not how they are implemented. The implementation of these units can be analog or digital. Quadrant I represents the operation of the domain-conversion unit 12: nonlinear input signals, which can be nonlinear code values (NLCVs), on axis 701 are converted by mapping them through transform 711 to form linear code values (LCVs) on axis 702. Quadrant II represents the operation of compensator 13: LCVs on axis 702 are mapped through transforms such as 721 and 722 to form changed linear code values (CLCVs) on axis 703.

[0050] Referring to Quadrant I, domain-conversion unit 12 receives NLCVs and converts them to LCVs. This conversion can preferably be performed with sufficient resolution to avoid objectionable visible artifacts such as contouring and crushed blacks. In digital systems, NLCV axis 701 can be quantized, as indicated in FIG. 7. LCV axis 702 should have thus sufficient resolution to represent the smallest change in transform 711 between two adjacent NLCVs. This is shown as NLCV step 712 and corresponding LCV step 713. As the LCVs are by definition linear, the resolution of the whole LCV axis 702 should be sufficient to represent step 713. The LCVs can thus preferably be defined with finer resolution than the NLCVs in order to avoid loss of image information. The resolution can be twice that of step 713 by analogy with the Nyquist sampling theorem.

[0051] Transform 711 is an ideal transform for a reference subpixel. It has no relationship to any subpixel or the panel as a whole. Specifically, transform 711 is not modified due to any V_{th} or V_{EL} variations. There can be one transform for all colors, or one transform for each color. The domain-conversion unit, through transform 711, advantageously decouples the image-processing path from the compensator, allowing the two to operate together without having to share information. This simplifies the implementation of both.

[0052] Referring to Quadrant II, compensator 13 changes LCVs to changed linear code values (CLCVs) on a per-subpixel basis, in response to the per-subpixel status signals. In this example, curves 721 and 722 represent the compensator's behavior for a first and a second subpixel, respectively. V_{th} differences will require curves such as 721 and 722 to shift left and right on axis 703. Consequently, the CLCVs will generally require a larger range than the LCVs in order to provide headroom for compensation, that is, to avoid clipping the compensation of subpixels with high V_{th} voltages.

[0053] Following the dash-dot arrows , an NLCV of 1 is transformed by the domain-conversion unit 12 through transform 711 to an LCV of 4, as indicated in Quadrant I. For a first subpixel, the compensator 13 will pass that through curve 721 as a CLCV of 32, as indicated in Quadrant II. For a second subpixel with a higher V_{th}, the LCV of 4 will be converted through curve 722 to a CLCV of 64. The compensator thus compensates for the differences between characteristics of the drive transistors in the plurality of EL subpixels, and for differences between the characteristics of the EL emitters in the plurality of EL subpixels.

[0054] In various embodiments, the domain-converter 12 can be implemented as a look-up table or function analogous to an LCD source driver to perform this conversion. The domain-converter can receive code values from an image-processing path of eight bits or more.

[0055] The compensator can take in an 11-bit linear code value representing the desired voltage and produce a 12-bit changed linear code value to send to a linear source driver 14. The linear source driver can then drive the gate electrode of the drive transistor of an attached EL subpixel in response to the changed linear code value. The compensator can have greater bit depth on its output than its input to provide headroom for compensation, that is, to extend the voltage range 78 to voltage range 79 and keep the same resolution across the new, expanded range, as required for minimum linear code value step 713. The compensator output range can extend below the range of curve 711 as well as above it, e.g. when curve 711 is the mean of many subpixels' I-V curves, so actual I-V curves are disposed on both sides of curve 711.

[0056] Each panel design can be characterized to determine what the maximum transistor and EL emitter differences will be over a production run, and the compensator and source drivers can have enough range to compensate.

Sequence of operations

[0057] Before mass-production of a particular OLED panel design begins, the design is characterized to determine resolution required in the domain-conversion unit 12 and in the compensator 13. Resolution required can be characterized in conjunction with a panel calibration procedure such as copending commonly-assigned US Application No. 11/734,934, "CALIBRATING RGBW DISPLAYS" by Alessi et al., filed April 13, 2007. These determinations can be made by those skilled in the art.

[0058] Once the design has been characterized, mass-production can begin. At a selected time, e.g. manufacturing time or another time before the operating life of the panel, one or more I-V curves are measured for each panel produced. These panel curves can be averages of curves for multiple subpixels. There can be separate curves for different colors, or for different regions of the panel. Current can be measured at enough drive voltages to make a realistic I-V curve; any errors in the I-V curve can affect the results. Also at manufacturing time, respective reference currents can be measured for each subpixel 15 on the panel and respective status signals computed. The I-V curves and reference currents are stored with the panel.

[0059] The EL subpixel 15 shown in FIGS. 2 and 8 is for an N-channel drive transistor and a non-inverted (common-cathode) EL structure: the EL emitter 202 is tied to the second supply electrode 205, which is the source electrode of drive transistor 201, higher voltages on the gate electrode 203 command more light output, and voltage supply 211 is more positive than second voltage supply 206, so current flows from 211 to 206. However, this invention is applicable to any combination of P- or N-channel drive transistors and non-inverted or inverted (common-anode) EL emitters, using appropriate well-known modifications to the circuits. This invention is also applicable to low-temperature polysilicon (LTPS), amorphous silicon (a-Si) or zinc oxide transistors. The drive transistor 201 and select transistors 36 can be any of these types, or other types known in the art.

[0060] In a preferred embodiment, the invention is employed in a panel that includes Organic Light Emitting Diodes (OLEDs), which are composed of small molecule or polymeric OLEDs as disclosed in, but not limited to, US Patent No. 4,769,292 by Tang et al. and US Patent No. 5,061,569 by VanSlyke et al. In this embodiment, each EL emitter is an OLED emitter. Many combinations and variations of organic light emitting diode materials can be used to fabricate such a panel. This invention also applies to EL emitters other than OLEDs. Although the modes of characteristic differences of other EL emitter types can be different than those described herein, the measurement, modeling, and compensation techniques of the present invention can still be applied.

PARTS LIST

[0061]

10	display system
11	nonlinear input signal
12	converter to voltage domain
13	compensator
14	linear source driver
15	EL subpixel
16	current-measurement circuit
30	EL panel
32a	column line
32b	column line
32c	column line
33	gate driver
34	row line
34a	row line
34b	row line
34c	row line
35	subpixel matrix
36	select transistor
41	measurement
42	measurement
43	difference
49	black-level measurement
61	coefficient generator
62	multiplier
63	adder
64	status memory
78	voltage range
79	voltage range
127	quadrant
137	quadrant
200	switch
201	drive transistor
202	EL emitter
203	gate electrode
204	first supply electrode
205	second supply electrode
206	voltage supply
207	first electrode
208	second electrode
210	current mirror unit
211	voltage supply
212	first current mirror
213	first current mirror output
214	second current mirror
215	bias supply
216	current-to-voltage converter
220	correlated double-sampling unit
221	sample-and-hold unit
222	sample-and-hold unit
223	differential amplifier
230	analog-to-digital converter
501	I-V curve
502	I-V curve
503	threshold voltage difference
504	current difference
510	measurement reference gate voltage
521	I-V curve
522	I-V curve
530	reference I-V curve
531	compensated I-V curve
532	compensated I-V curve
541	error curve
542	error curve
601	subpixel location
602	commanded voltage
603	compensated voltage
701	axis
702	axis
703	axis
711	transform
712	step
713	step
721	transform
722	transform
1002	storage capacitor
1011	bus line
1012	sheet cathode

Claims

1. An apparatus for providing analog drive transistor control signals to the gate electrodes (203) of drive transistors (201) in a plurality of electroluminescent (EL) subpixels (15) in an EL panel (30), including a first voltage supply (211), a second voltage supply (206), and the plurality of EL subpixels (15) in the EL panel (30);
each EL subpixel (15) including an EL emitter (202) and a drive transistor (201) with a first supply electrode (204) electrically connected to the first voltage supply (211) and a second supply electrode (205) electrically connected to a first electrode (207) of the EL emitter (202); and each EL emitter (202) having a second electrode (208) electrically connected to the second voltage supply (206), the apparatus further comprising:

a) a measuring circuit (16) configured to measure a respective current passing through the first and the second voltage supplies (211, 206) at a predetermined measurement gate voltage (510) to provide a status signal for each subpixel (15) representing a characteristic of the drive transistor (201) and EL emitter (202) in that EL subpixel, wherein the respective currents produced at a first EL subpixel and second EL subpixel differ by a current difference (504) so that an offset and a gain are usable for the subsequent compensation rather than fully stored I-V curves (501, 502) for each subpixel and wherein each status signal comprises the gain and the offset;

b) means for providing a linear code value (12) for each subpixel (15);
c) a compensator (13) configured to change the linear code values (12) in response to the corresponding status signals to compensate for the differences between the characteristics of the drive transistors (201) in the plurality of EL subpixels (15), and for differences between the characteristics of the EL emitters (202) in the plurality of EL subpixels (15); and
d) a linear source driver (14) configured to produce the analog drive transistor control signals in response to the changed linear code values so as to drive the gate electrodes (203) of the drive transistors (201), **characterized in that** the measuring circuit (16) includes:

i) a current to voltage converter (216) configured to produce a voltage signal; and
ii) a correlated double-sampling unit (220) responsive to the voltage signal configured to provide the status signal to the compensator (13).

2. The apparatus of claim 1 wherein each EL emitter (202) is an OLED emitter.

3. The apparatus of claim 1 wherein each drive transistor (201) is a low-temperature polysilicon transistor.

4. The apparatus of claim 1, wherein the measuring circuit (16) further includes:

iii) a first current mirror (212) configured to provide the current passing through the first and the second voltage supplies (211,206) to the current to voltage converter (216);
iv) a switch (200) configured to selectively electrically connect the first current mirror (212) to the first voltage supply (211); and
v) a second current mirror (214) connected to the first current mirror (212) configured to reduce impedance of the first current mirror.

5. The apparatus of claim 1, further comprising a memory (64) configured to store the corresponding status signals of each subpixel, and wherein the compensator (13) is configured to use the stored corresponding status signals while producing the respective changed linear code values.

6. The apparatus of claim 1, wherein the linear source driver is configured to produce one or more test analog drive transistor control signals at the selected time, wherein the measurement circuit is configured to measure a current corresponding to each of the one or more test analog drive transistor control signals, and wherein each status signal comprises the one or more respective currents and the one or more test analog drive transistor control signals.

7. The apparatus of claim 1, further including means configured to receive (11) a nonlinear input signal and for converting (12) the nonlinear input signal to the linear code value.

8. The apparatus of claim 1, wherein the selected time is before the operating life of the EL panel.

Patentansprüche

1. Vorrichtung zum Bereitstellen von analogen Treibertransistorsteuersignalen für die Gate-Elektrode (203) von Treibertransistoren (201) in einer Vielzahl von elektrolumineszenten (EL) Unterpixeln (15) in einem EL-Paneel (30), das eine erste Spannungszufuhr (211), eine zweite Spannungszufuhr (206) und die Vielzahl von EL-Unterpixeln (15) in dem EL-Paneel (30) umfasst;
wobei jedes EL-Unterpixel (15) einen EL-Emitter (202) und einen Treibertransistor (201) mit einer ersten Zufuhrelektrode (204), die elektrisch mit der ersten Spannungszufuhr (211) verbunden ist, und einer zweiten Zufuhrelektrode (205), die elektrisch mit einer ersten Elektrode (207) des EL-Emitters (202) verbunden ist, umfasst; und jeder EL-Emitter (202) eine zweite Elektrode (208) aufweist, die elektrisch mit der zweiten Spannungszufuhr (206) verbunden ist, wobei die Vorrichtung weiterhin umfasst:

a) eine Messschaltung (16), die konfiguriert ist, um einen jeweiligen Strom zu messen, der durch die erste und die zweite Spannungszufuhr (211, 206) bei einer vorbestimmten Mess-Gatespannung (510) fließt, um ein Statussignal für jedes Unterpixel (15) bereitzustellen, das eine Eigenschaft des Treibertransistor (201) und des EL-Emitters (2b2) in jenem EL-Unterpixel darstellt, wobei die jeweiligen Ströme, die bei einem ersten EL-Unterpixel und einem zweiten EL-Unterpixel erzeugt werden, um eine Stromdifferenz (504) derart voneinander abweichen, dass ein Offset und ein Zuwachs für die nachfolgende Kompensierung anstelle von voll gespeicherten I-V-Kurven (501, 502) für jedes Unterpixel verwendbar sind, und wobei jedes Statussignal den Zuwachs und den Offset umfasst;
b) eine Einrichtung zum Bereitstellen eines linearen Codewerts (12) für jedes Unterpixel (15);
c) einen Kompensator (13), der konfiguriert ist, um die linearen Codewerte (12) in Antwort auf die entsprechenden Statussignale zu ändern, um die Differenzen zwischen den Eigenschaften der Treibertransistoren (201) in der Vielzahl von

EL-Unterpixeln (15) und die Differenzen zwischen den Eigenschaften der EL-Emitter (202) in der Vielzahl von EL-Unterpixeln (15) zu kompensieren; und

d) einen linearen Quellentreiber (14), der konfiguriert ist, um die analogen Treibertransistorsteuersignale in Antwort auf die geänderten linearen Codewerte derart zu erzeugen, um die Gate-Elektrode (203) der Treibertransistor (201) zu treiben,

dadurch gekennzeichnet, dass
die Messschaltung (16) umfasst:

i) einen Strom-zu-Spannungskonverter (216), der konfiguriert ist, um ein Spannungssignal zu erzeugen; und

ii) eine Einheit (220) für eine korrelierte Doppelabtastung, die auf das Spannungssignal reagiert und konfiguriert ist, um das Statussignal dem Kompensator (13) bereitzustellen.

2. Vorrichtung gemäß Anspruch 1, wobei jeder EL-Emitter (202) ein OLED-Emitter ist.

3. Vorrichtung gemäß Anspruch 1, wobei jeder Treibertransistor (201) ein Polysilizium-Transistor niedriger Temperatur ist.

4. Vorrichtung gemäß Anspruch 1, wobei die Messschaltung (16) weiterhin umfasst:

iii) einen ersten Stromspiegel (212), der konfiguriert ist, um den durch die erste und die zweite Spannungszufuhr (211, 206) fließenden Strom dem Strom-zu-Spannungskonverter (216) bereitzustellen;

iv) einen Schalter (200), der konfiguriert ist, um den ersten Stromspiegel (212) mit der ersten Spannungszufuhr (211) elektrisch zu verbinden; und

v) einen zweiten Stromspiegel (214), der mit den ersten Stromspiegel (212) verbunden ist und konfiguriert ist, um eine Impedanz des ersten Stromspiegels zu verringern.

5. Vorrichtung gemäß Anspruch 1, weiterhin umfassend einen Speicher (64), der konfiguriert ist, um die entsprechenden Statussignale von jedem Unterpixel zu speichern, und wobei der Kompensator (13) konfiguriert ist, um die gespeicherten entsprechenden Statussignale zu verwenden, während die jeweiligen geänderten linearen Codewerte erzeugt werden.

6. Vorrichtung gemäß Anspruch 1, wobei der lineare Quellentreiber konfiguriert ist, um ein oder mehrere analoge Testtreibertransistorsteuersignale zu der ausgewählten Zeit zu erzeugen, wobei die Messschaltung konfiguriert ist, um einen Strom entsprechend jedem des einen oder der mehreren analogen Testtreibertransistorsteuersignale zu messen, und wobei jedes Statussignal den einen oder die mehreren jeweiligen Ströme und das eine oder die mehreren analogen Testtreibertransistorsteuersignale umfasst.

7. Vorrichtung gemäß Anspruch 1, weiterhin umfassend eine Einrichtung, die konfiguriert ist, um ein nicht-lineares Eingangssignal zu empfangen (11) und zum Umwandeln (12) des nicht-linearen Eingangssignals in den linearen Codewert.

8. Vorrichtung gemäß Anspruch 1, wobei die ausgewählte Zeit vor dem aktiven Betrieb des EL-Paneels liegt.

Revendications

1. Appareil pour fournir des signaux analogiques de commande de transistors d'attaque aux électrodes grilles (203) de transistors d'attaque (201) dans une pluralité de sous-pixels électroluminescents (EL) (15) dans un panneau EL (30), incluant une première alimentation (211) de tension, une deuxième alimentation (206) de tension, et la pluralité de sous-pixels EL (15) dans le panneau EL (30) ;
chaque sous-pixel EL (15) incluant un émetteur EL (202) et un transistor d'attaque (201) avec une première électrode (204) d'alimentation électriquement connectée à la première alimentation (211) de tension et une deuxième électrode (205) d'alimentation électriquement connectée à une première électrode (207) de l'émetteur EL (202) ; et chaque émetteur EL (202) ayant une deuxième électrode (208) électriquement connectée à la deuxième alimentation (206) de tension, l'appareil comprenant en outre :

a) un circuit de mesure (16) configuré pour mesurer un courant respectif traversant les première et deuxième alimentations (211, 206) de tension à une tension de grille (510) de mesure prédéterminée pour fournir un signal de statut pour chaque sous-pixel (15) représentant une caractéristique du transistor d'attaque (201) et de l'émetteur EL (202) dans ce sous-pixel EL, dans lequel les courants respectifs produits au niveau d'un premier sous-pixel EL et d'un deuxième sous-pixel EL diffèrent d'une différence (504) de courant de telle sorte qu'un décalage et un gain sont utilisables pour la compensation suivante plutôt que des courbes I-V (501, 502) totalement stockées pour chaque sous-pixel et dans lequel chaque signal de statut comprend le gain et le décalage ;

b) un moyen pour fournir une valeur de code linéaire (12) pour chaque sous-pixel (15) ;
c) un compensateur (13) configuré pour changer les valeurs de code linéaire (12) en réponse aux signaux de statut correspondants pour compenser les différences entre les caractéristiques des transistors d'attaque (201) dans la pluralité de sous-pixels EL (15), et des différences entre les caractéristiques des émetteurs EL (202) dans la pluralité de sous-pixels EL (15) ; et
d) un pilote de source linéaire (14) configuré pour produire les signaux analogiques de commande de transistors d'attaque en réponse aux valeurs de code linéaire changées de manière à piloter les électrodes grilles (203) des transistors d'attaque (201),

caractérisé en ce que le circuit de mesure (16) inclut :

i) un convertisseur (216) de courant en tension configuré pour produire un signal de tension ; et
ii) une unité (220) de double échantillonnage corrélé répondant au signal de tension configurée pour fournir le signal de statut au compensateur (13).

2. Appareil selon la revendication 1 dans lequel chaque émetteur EL (202) est un émetteur OLED.

3. Appareil selon la revendication 1 dans lequel chaque transistor d'attaque (201) est un transistor de polysilicium basse température.

4. Appareil selon la revendication 1 dans lequel le circuit de mesure (16) inclut en outre :

iii) un premier miroir de courant (212) configuré pour fournir le courant traversant les première et deuxième alimentations (211, 206) de tension au convertisseur (216) de courant en tension ;
iv) un commutateur (200) configuré pour connecter électriquement sélectivement le premier miroir de courant (212) à la première alimentation (211) de tension ; et
v) un deuxième miroir de courant (214) connecté au premier miroir de courant (212) configuré pour réduire une impédance du premier miroir de courant.

5. Appareil selon la revendication 1, comprenant en outre une mémoire (64) configurée pour stocker les signaux de statut correspondants de chaque sous-pixel, et dans lequel le compensateur (13) est configuré pour utiliser les signaux de statut correspondants stockés lors de la production des valeurs de code linéaire changées respectives.

6. Appareil selon la revendication 1, dans lequel le pilote de source linéaire est configuré pour produire un ou plusieurs signaux analogiques de commande de transistors d'attaque de test au moment sélectionné, dans lequel le circuit de mesure est configuré pour mesurer un courant correspondant à chacun du ou des signaux analogiques de commande de transistors d'attaque de test, et dans lequel chaque signal de statut comprend le ou les courants respectifs et le ou les signaux analogiques de commande de transistors d'attaque de test.

7. Appareil selon la revendication 1, incluant en outre un moyen configuré pour recevoir (11) un signal d'entrée non linéaire et pour convertir (12) le signal d'entrée non linéaire en la valeur de code linéaire.

8. Appareil selon la revendication 1, dans lequel le moment sélectionné est avant la durée de vie opérationnelle du panneau EL.

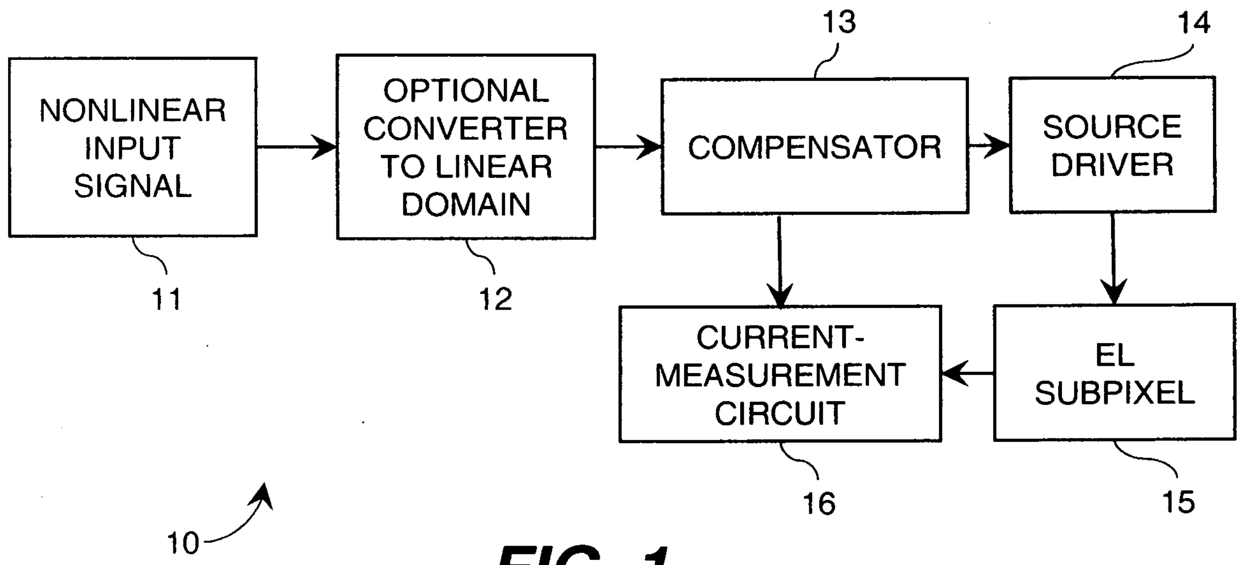
13
14
NONLINEAR INPUT SIGNAL
OPTIONAL CONVERTER TO LINEAR DOMAIN
COMPENSATOR
SOURCE DRIVER
11
12
CURRENT-MEASUREMENT CIRCUIT
EL SUBPIXEL
16
15
10

FIG. 1

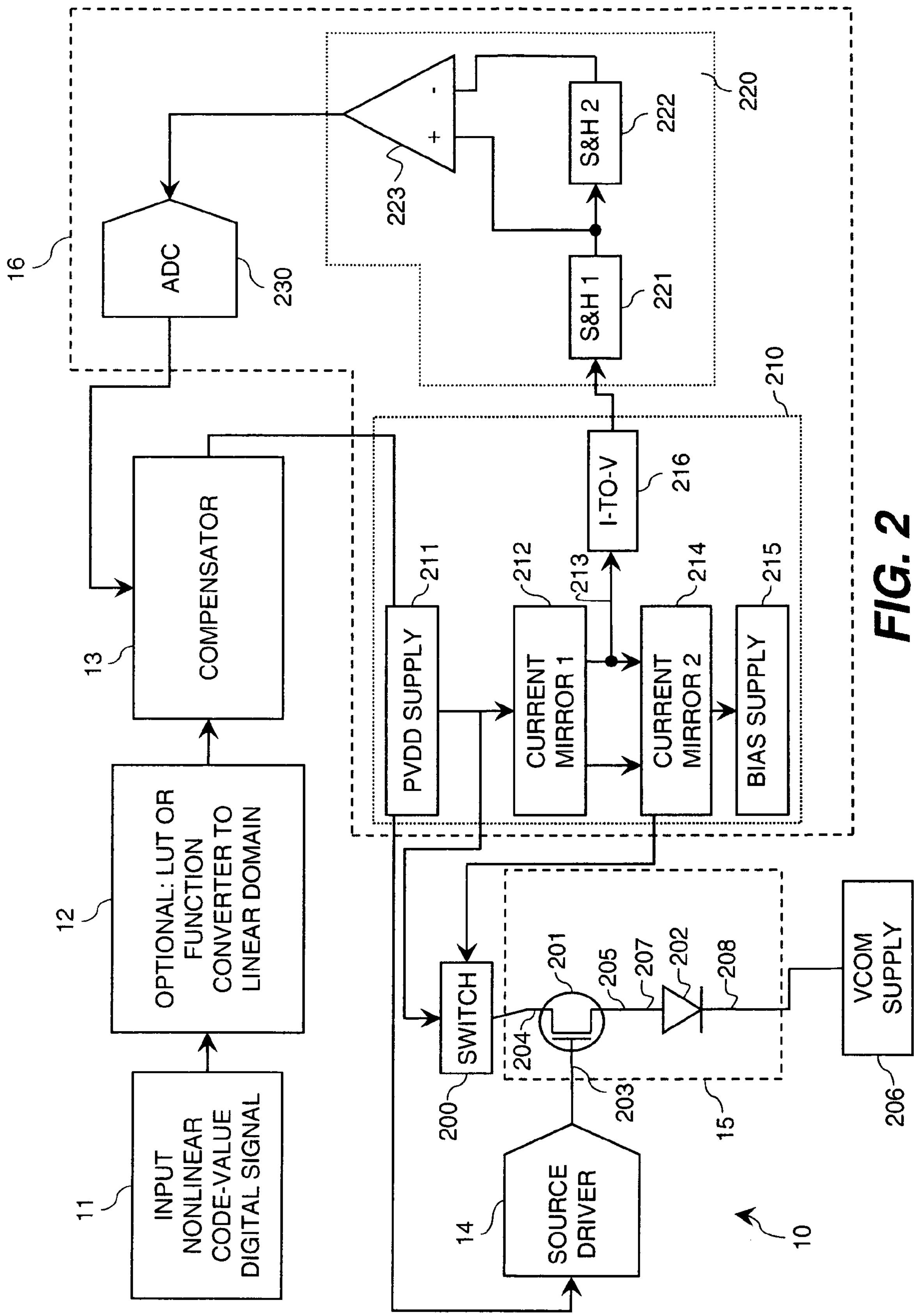
INPUT NONLINEAR CODE-VALUE DIGITAL SIGNAL
11
OPTIONAL: LUT OR FUNCTION CONVERTER TO LINEAR DOMAIN
12
COMPENSATOR
13
SOURCE DRIVER
14
15
16
ADC
230
PVDD SUPPLY
211
CURRENT MIRROR 1
212
213
CURRENT MIRROR 2
214
BIAS SUPPLY
215
I-TO-V
216
210
S&H 1
221
S&H 2
222
223
+
-
220
SWITCH
200
201
202
203
204
205
207
208
VCOM SUPPLY
206
10

FIG. 2

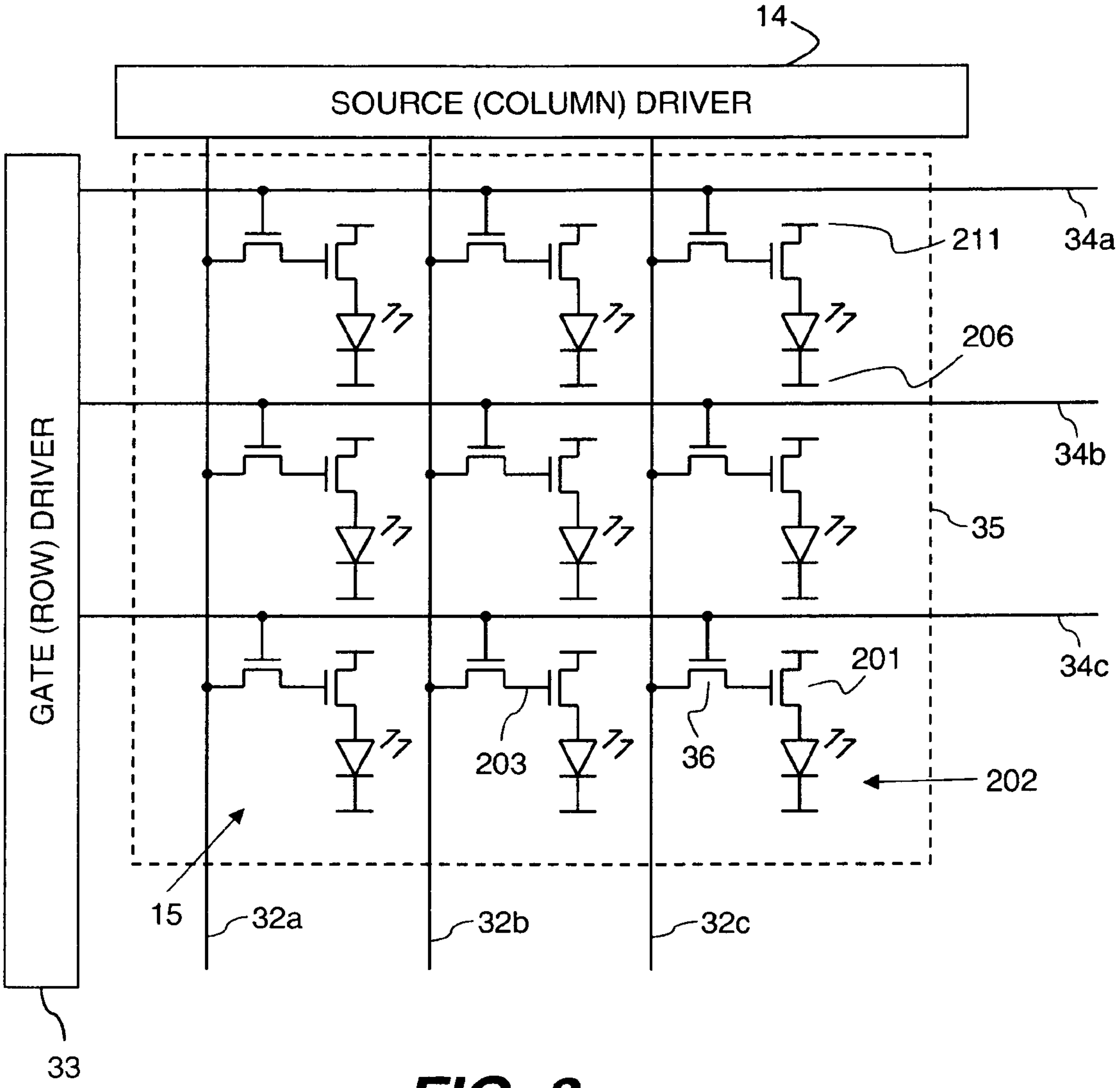
14
SOURCE (COLUMN) DRIVER
GATE (ROW) DRIVER
211
34a
206
34b
35
34c
201
203
36
202
15
32a
32b
32c
33
30

FIG. 3

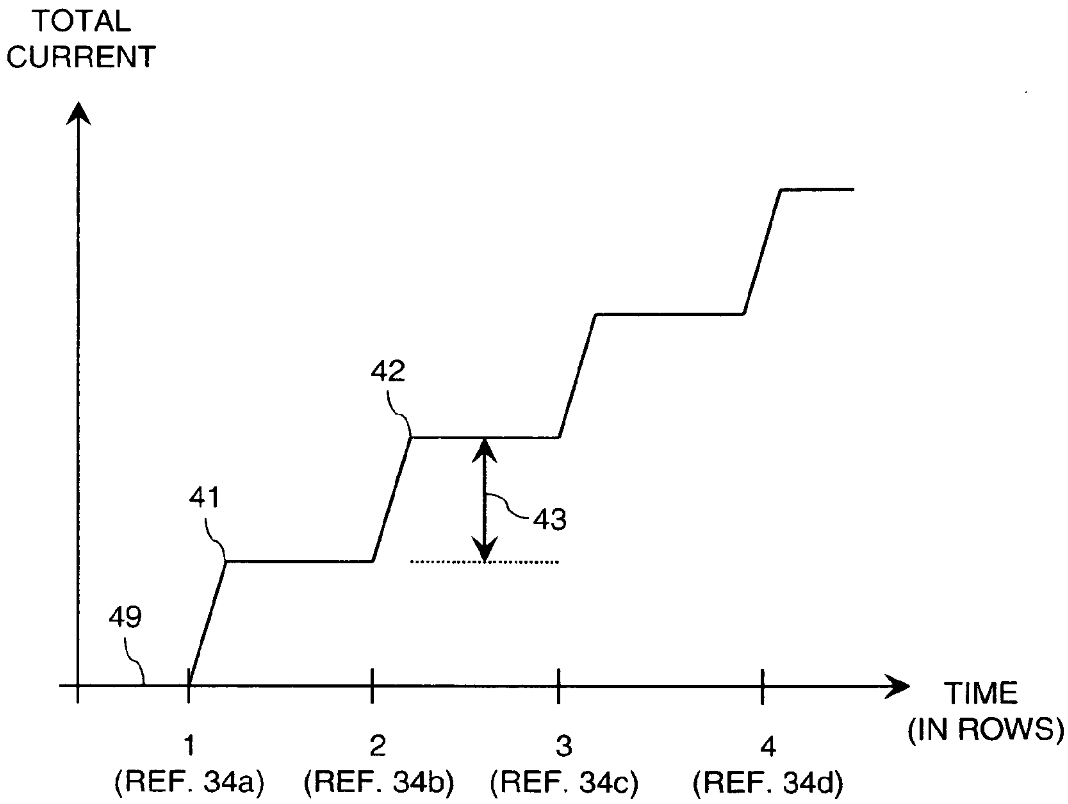
TOTAL
CURRENT
42
41
43
49
TIME
(IN ROWS)
1
(REF. 34a)
2
(REF. 34b)
3
(REF. 34c)
4
(REF. 34d)

FIG. 4

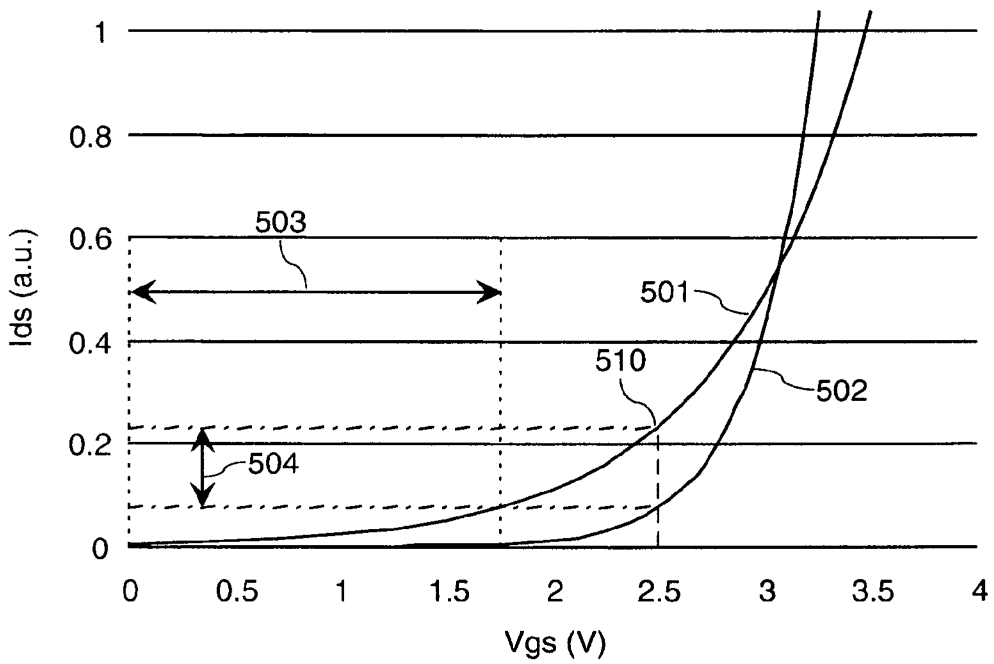

FIG. 5A

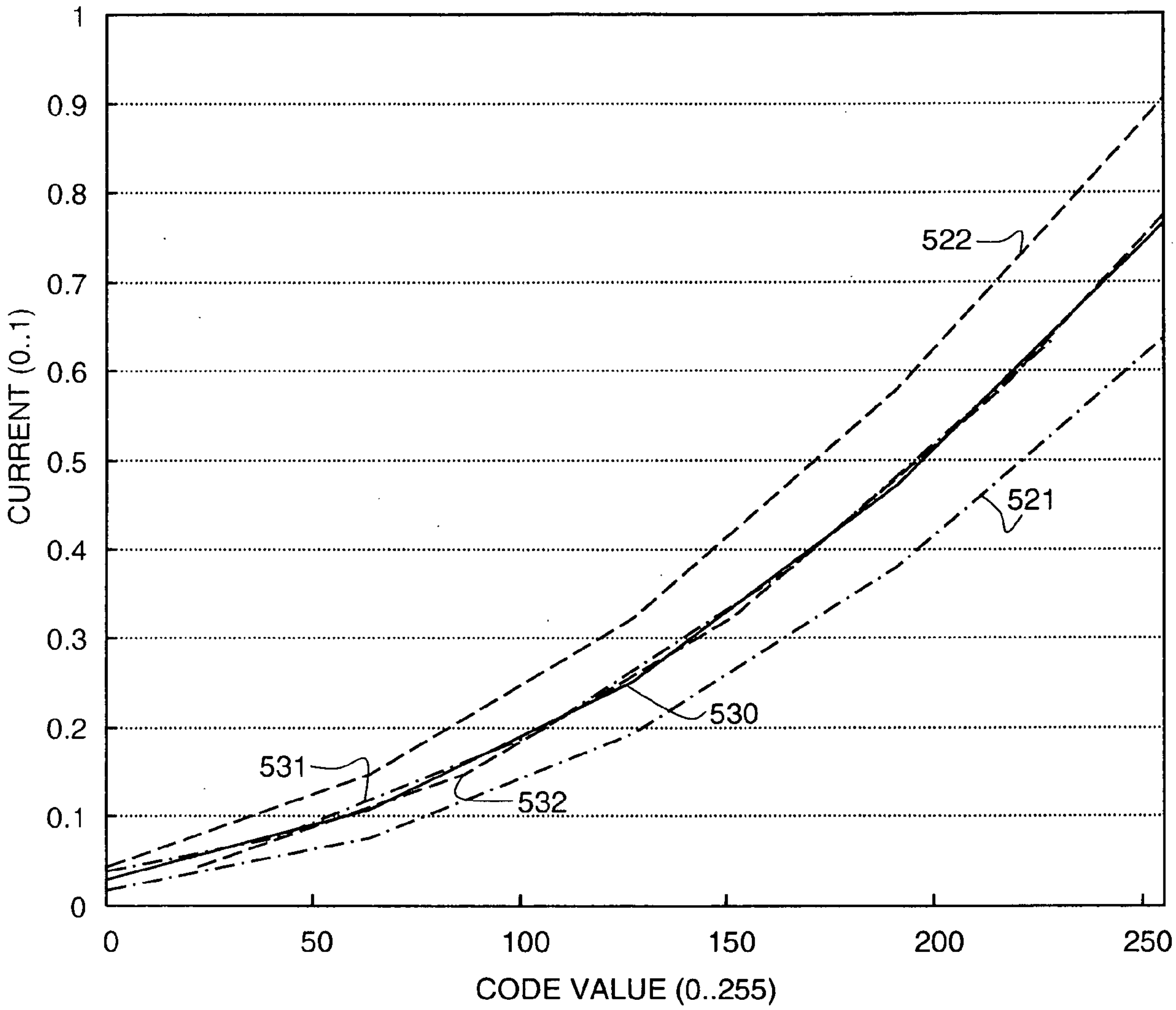
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
CURRENT (0..1)
0
50
100
150
200
250
CODE VALUE (0..255)
522
521
530
531
532

FIG. 5B

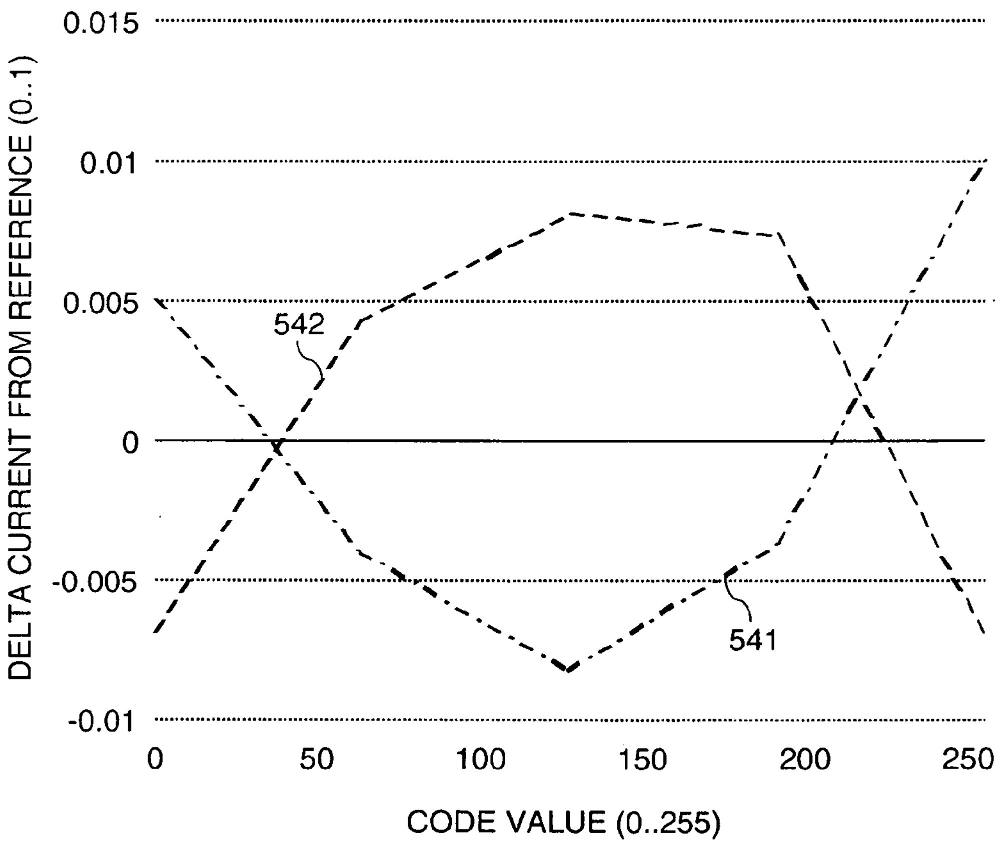
0.015
0.01
0.005
0
-0.005
-0.01
DELTA CURRENT FROM REFERENCE (0..1)
542
541
0
50
100
150
200
250
CODE VALUE (0..255)

FIG. 5C

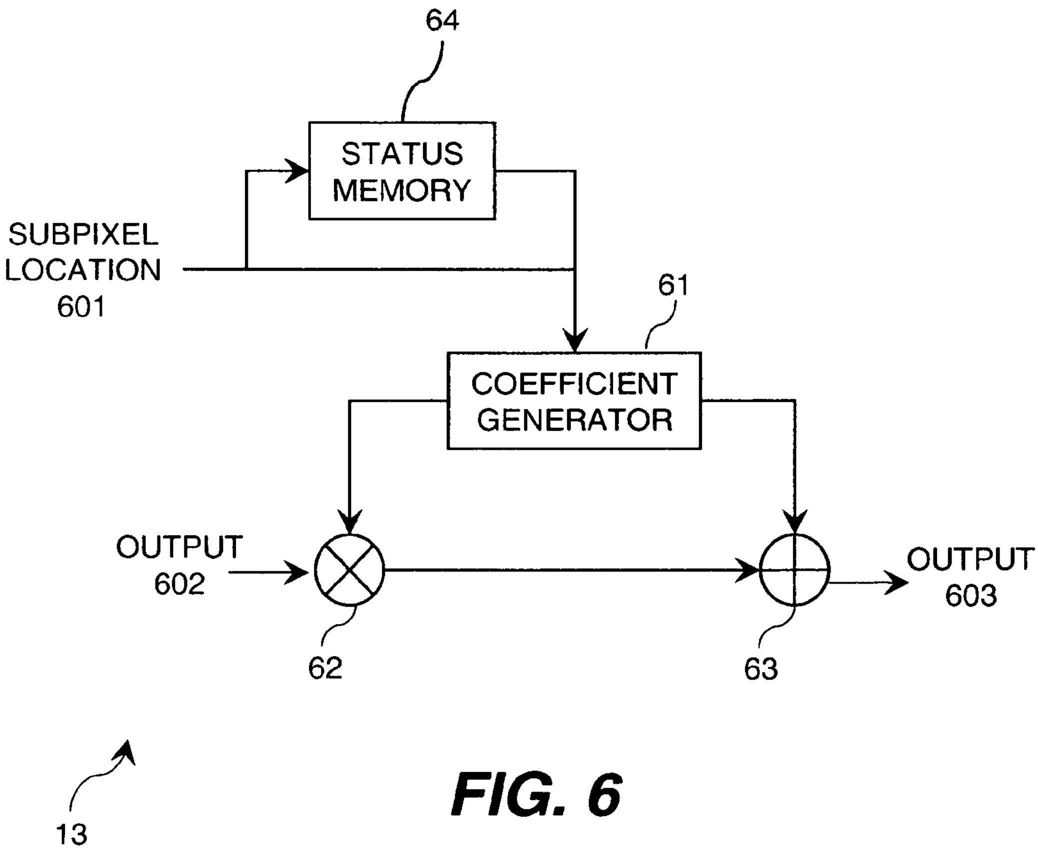
64
STATUS
MEMORY
SUBPIXEL
LOCATION
601
61
COEFFICIENT
GENERATOR
OUTPUT
602
OUTPUT
603
62
63
13

FIG. 6

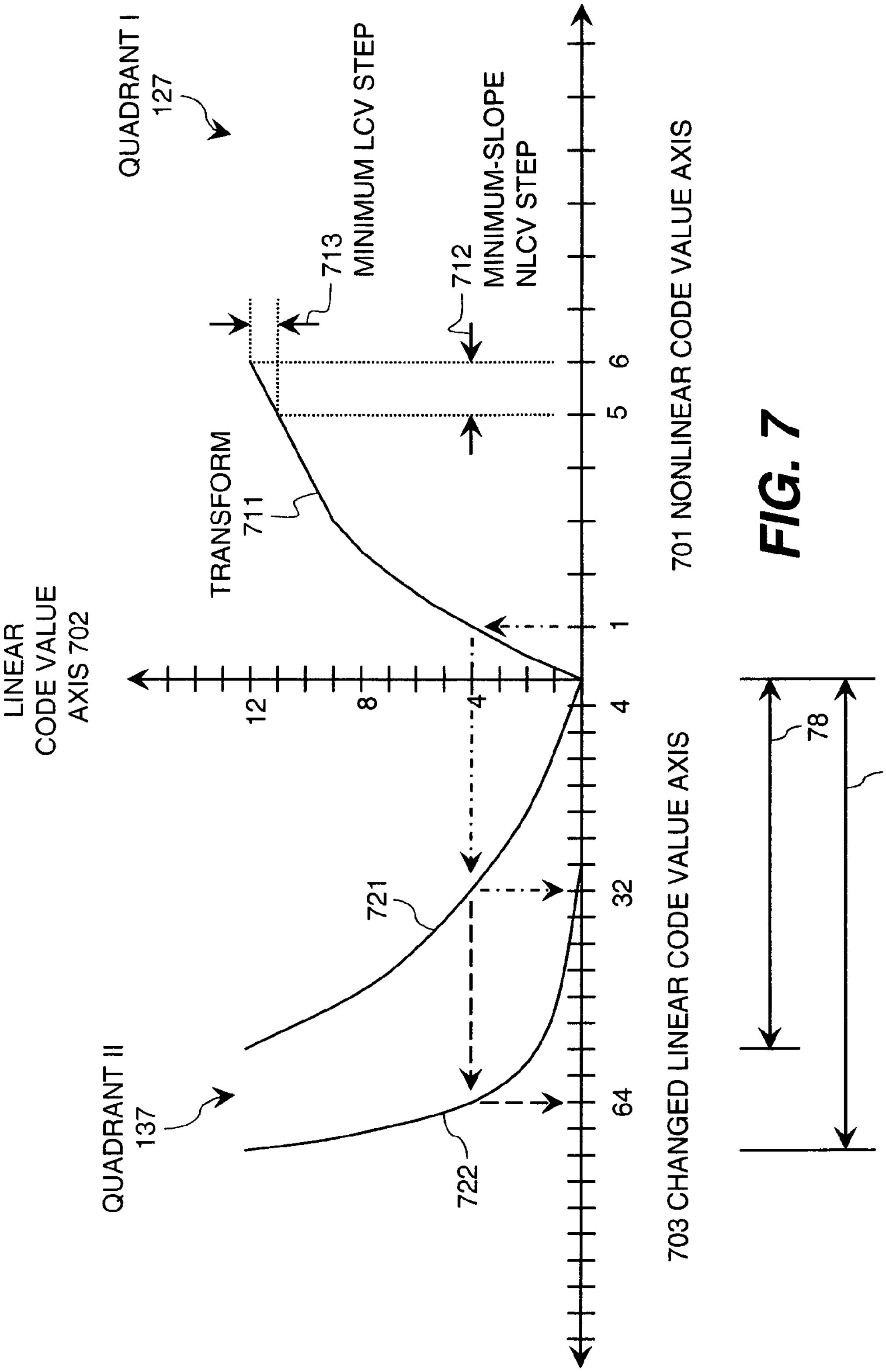
QUADRANT I
127
MINIMUM LCV STEP
713
MINIMUM-SLOPE
NLCV STEP
712
LINEAR
CODE VALUE
AXIS 702
TRANSFORM
711
12
8
4
1
5
6
701 NONLINEAR CODE VALUE AXIS
4
32
64
721
722
QUADRANT II
137
703 CHANGED LINEAR CODE VALUE AXIS
78
79

FIG. 7

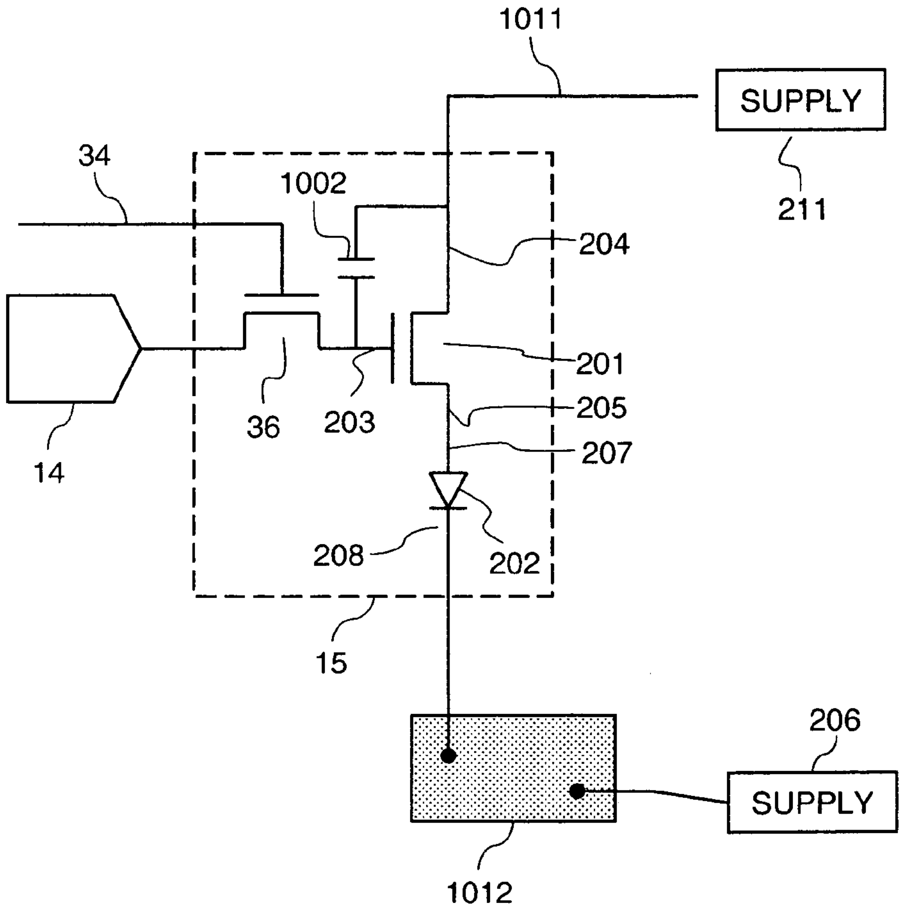
1011
SUPPLY
211
34
1002
204
201
205
207
14
36
203
208
202
15
206
SUPPLY
1012

FIG. 8

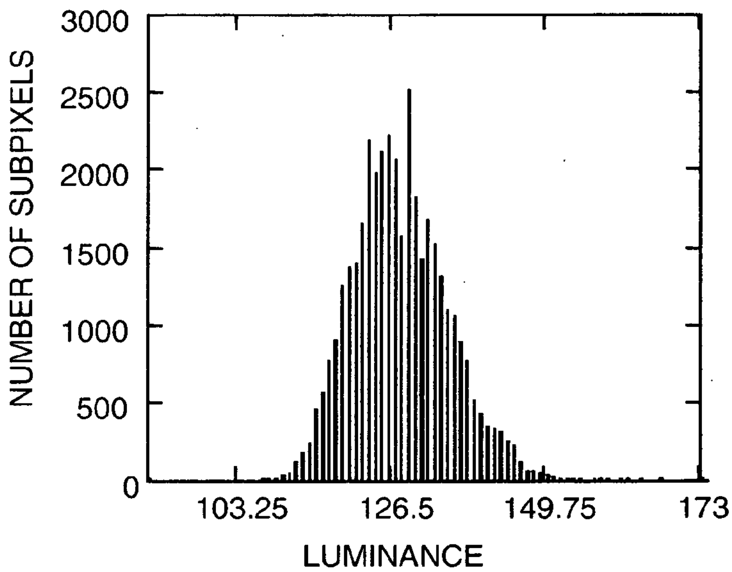
3000
2500
2000
1500
1000
500
0
NUMBER OF SUBPIXELS
103.25
126.5
149.75
173
LUMINANCE

FIG. 9

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 20030122813 A, Ishizuki **[0006]**
- US 6081073 A, Salam **[0007]**
- US 6473065 B, Fan **[0008]**
- US 7345660 B, Mizukoshi **[0009]**
- US 6414661 B, Shen **[0010]**
- US 20050007392 A, Kasai **[0011]**
- US 6989636 B, Cok **[0011]**
- US 6897842 B, Gu **[0011]**
- WO 2005101360A1 A **[0011]**
- US 20070290958 A1 **[0011]**
- WO 2009085113 A2 **[0011]**
- WO 2005116971 A, Kawabe **[0019]**
- US 11734934 B **[0057]**
- US 4769292 A, Tang **[0060]**
- US 5061569 A, VanSlyke **[0060]**

Non-patent literature cited in the description

- Thin Film Transistors: Materials and Processes, Vol. 2, Polycrystalline Thin Film Transistors. Kluwer Academic Publishers, 2004, vol. 2, 412 **[0004]**
- **LURCH, N.** Fundamentals of electronics. John Wiley & Sons, 1971, 110 **[0039]**
- Digital Color Management: encoding solutions. **GIORGIANNI ; MADDEN.** Reading. Addison-Wesley, 1998, 283-295 **[0048]**

专利名称(译)	电致发光显示器初始非均匀性补偿的驱动信号		
公开(公告)号	EP2351013B1	公开(公告)日	2018-09-19
申请号	EP2009756586	申请日	2009-11-12
[标]申请(专利权)人(译)	全球OLED TECH		
申请(专利权)人(译)	全球OLED科技有限责任公司		
当前申请(专利权)人(译)	全球OLED科技有限责任公司		
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发明人	LEON, FELIPE, ANTONIO WHITE, CHRISTOPHER, JASON PARRETT, GARY PRIMERANO, BRUNO		
IPC分类号	G09G3/32		
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优先权	12/274559 2008-11-20 US		
其他公开文献	EP2351013A1		
外部链接	Espacenet		

摘要(译)

具有2T1C子像素的电致发光（EL）面板被补偿初始不均匀性（“mura”）。在选定的时间测量每个子像素的电流，以提供表示子像素的特性的状态信号。补偿器接收线性代码值并根据状态信号进行更改。线性源驱动程序使用更改的代码值驱动面板。

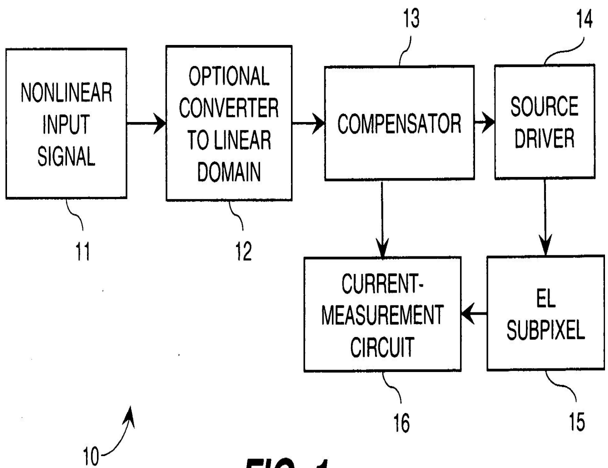

FIG. 1