Description

This invention relates to a display device of the kind as referred to in the pre-characterizing part of patent claim 1. Such a display device is known from GB-A-20 70 308.

Prior art devices for the liquid crystal active matrix display, which consists of 3-terminal switching elements represented by TFTs or 2-terminal non-linear switching elements represented by MIMs (Metal Insulator Metal) and a liquid crystal layer superposed thereon for displaying images are described in JP-A-61-128292 (Fig. 1), JP-A-61-116334 (Fig. 2) and SID 84 DIGEST (1984) pp. 304-307 (Fig. 3).

The signal side circuit of the liquid crystal display indicated in Fig. 1 is composed of a shift register 123, a latch circuit 124 and a group of 2-value switching elements 125.

The group of 2-value switching elements 125 is constituted by one-out-of-two multiplexers, each of which selects either one of the V_D or GND levels and outputs it as a signal voltage.

This signal voltage is inputted in liquid crystal elements 126b through TFTs 126a in a TFT liquid crystal panel 126. The brightness of a liquid crystal element 126b varies according to the level of the signal voltage. As the result, an image is displayed on the TFT liquid crystal panel 126.

However, by this driving method, in order to obtain a number of gradations in brightness greater than 2, the signal voltage should have a plurality of levels corresponding to the number of gradations. Consequently it is necessary to switch the voltage levels by using a great number of switches.

For this reason this method is disadvantageous, not only because the construction of the signal circuit is complicated but also because the cost for ICs increases, when it is constructed by using ICs.

On the other hand Fig. 2 indicates a prior art example of the intermediate gradation displaying driving circuit. A video signal V_s (analogue voltage) is time-sequentially sampled by a sampling holder 129 and inputted in TFTs 32a through a buffer circuit.

For example for the TV display, when it is supposed that the number of pixels in the horizontal direction of a TFT liquid crystal panel 132 is 500, the sampling time of the sampling switch 129 is about 0.1 µs. Consequently the driving frequency of a shift register 128 is 10 MHz. When the video signal is sampled with such a high speed, the sampling is imperfect and it is not possible to obtain any uniform display.

Further for a highly fine display having a number of displaying pixels of 1000 x 1000 the driving frequency of the shift register 128 is further increased, which gives rise to a problem such as cost-up, etc., specifically when it is composed of ICs.

Fig. 3 shows another prior art example, in which reference numeral 133 is an X-driving circuit; 134 is a Y-driving circuit; 135 is an MIM two-terminal element; 36 is a liquid crystal element; and 137 is an electric switch.

A display signal inputted in the X-driving circuit 133 is sampled successively by the electronic switch 137 during one horizontal scanning period and applied to the MIM two-terminal element 135.

If the display signal were a video (analogue) signal, the gray scale display would be possible. However, by this method, when the number of pixels in the horizontal direction is increased, the sampling time is shortened. As the result, an insufficiently high voltage is applied to the liquid crystal element 136, which gives rise to problems that the contrast is lowered, that no uniform display can be obtained, etc.

That is, by the prior art gray scale displaying methods, the sampling frequency for the video signal is too high and further the construction of the output stage of the driving circuit is complicated, which gave rise to problems, specifically when a circuit for driving a highly fine display should be integrated.

GB-A-20 70 308 discloses a gray scale display device comprising: a display panel including a plurality of scanning electrodes, a plurality of signal electrodes intersecting the plurality of scanning electrodes, a plurality of switching elements respectively formed at positions corresponding to intersections of scanning electrodes and the plurality of signal electrodes, and a plurality of display bodies, one display body connected to each switching element, each switching element responsive to a signal on the scanning electrodes of the corresponding intersection for applying a signal voltage from the signal electrode of the corresponding intersection to the corresponding display body, each display body responsive to the applied signal voltage for exhibiting a brightness controlled by the amplitude of the applied signal voltage; digital signal generating means for generating digital signals including gray scale information; holding means for temporarily holding digital signals including gray scale information inputted in a unit of a predetermined number of bits and corresponding at least to the plurality of signal electrodes; digital-time function transforming means for transforming the digital signals from the holding means into time function signals for each signal electrodes; means for providing a brightness reference signal; time function-gray scale transforming means for sampling the brightness reference signal, responding to the time function signal, and generating gray scale

signals based on the brightness reference signal at the times of the time function signals; storage means for holding the generated gray scale signals; and scanning voltage generating means for generating a scanning voltage for successively scanning the plurality of scanning electrodes.

The object of this invention is to provide a gray scale displaying device capable of solving the problems described above and most suitable for constructing it by using ICs.

The above object can be achieved by providing a gray scale display device with the features of claim 1.

Dependent claims are directed on features of preferred embodiments of the invention as claimed in claim 1.

The time function-gray scale transforming means, in which a brightness reference signal is inputted, samples the signal, responding to time function signals such as a panel phase signal, a pulse width signal, etc. and generates a signal voltage.

As the result not only the circuit for generating the signal voltage can be simplified, but also the operation speed of the circuit can be lowered.

Figs. 1 to 3 are block diagrams illustrating three different prior art liquid crystal display devices;

Fig. 4 is a block diagram illustrating an embodiment of this invention;

Fig. 5 is a block diagram illustrating the sampling circuit in Fig. 4 in detail;

Figs. 6 to 12 are graphs showing waveforms of signals at various points in the circuit indicated in Fig. 5 in blocks;

Fig. 13 shows another embodiment for the sampling circuit indicated in Fig. 4;

Fig. 14 indicates graphs showing waveforms of signals at various points in the circuit indicated in Fig. 13 in blocks;

Fig. 15 shows still another embodiment for the sampling circuit indicated in Fig. 4;

Figs. 16 and 17 are graphs showing waveforms of signals at various points in the circuit indicated in Fig. 15 in blocks;

Fig. 18 is a block diagram illustrating an embodiment of the sampling control circuit;

Fig. 19 is a block diagram illustrating still another embodiment for the scanning circuit indicated in Fig. 4;

Fig. 20 indicates graphs showing waveforms of signals for explaining the operation of the circuit indicated in Fig. 19 in blocks;

Fig. 21 is a block diagram illustrating still another embodiment of the sampling control circuit indicated in Fig. 4;

Figs. 22 and 23 are graphs showing waveforms of signals at various points in the circuit indicated in Fig. 21 in blocks;

Figs. 24 and 25 are block diagrams illustrating two different embodiments for the color display drive;

Fig. 26 is a block diagram illustrating an embodiment of the display system;

Fig. 27 is a block diagram illustrating still another embodiment of the sampling control circuit indicated in Fig. 4;

Figs. 28 to 30 are graphs showing waveforms of signals at various points in the circuit of the embodiment indicated in Fig. 27;

Fig. 31 is a block diagram illustrating still another embodiment of the sampling control circuit; and

Fig. 32 is a graph indicating waveforms of various signals generated by the reference signal generating circuit 80 indicated in Fig. 31.

Hereinbelow several embodiments of this invention will be explained in detail. Fig. 4 illustrates an example of the construction of a whole display device according to this invention. The device consists of a TFT liquid crystal panel 1, a scanning circuit 2, a sampling circuit 3 acting as time function-gray scale transforming means, a sampling control circuit 4 acting as digital-time function transforming means, a control circuit 5, a frame memory 6 and a video circuit 7.

The TFT liquid crystal panel 1 is composed of TFTs 1a acting as switching elements, a plurality of signal lines 1c feeding a liquid crystal layer 1b and the TFTs 1a with voltage and a plurality of scanning lines 1d. The scanning circuit 2 generates a signal corresponding to a scanning voltage for scanning the signal lines 1d one after another, which is applied to a scanning line 1d.

In the sampling control circuit 4 are inputted a data signal and a timing signal determining the state of the brightness of the liquid crystal 1b and in the sampling circuit 3 is inputted a brightness reference signal.

Further another timing signal is inputted in the scanning circuit 3.

Now the operation of each of the parts will be explained below concretely. Fig. 5 shows an embodiment of the sampling circuit 3, when it is constructed by electronic switches 8 to 10. The electronic switches 8 - 10 may be constructed by TFTs or MOS transistors, but they are not restricted thereto.

In the scanning circuit 2 are inputted an FST signal and a CKV signal as timing signals. Scanning signals V_{g1} to V_{gn} are outputted, based on these signals.

On the other hand, in the sampling control circuit 4 is inputted a digital data signal DATA determining the display state of the liquid crystal, which is transformed into sampling signals ϕ_1 to ϕ_m.

The amplitude of the sampling signals ϕ_1 to ϕ_m is determined by the logic level of the electronic switches constituting the sampling control circuit 4. For example, when the electronic switches are constituted by MOS transistors, it is 0 to 5 V. The amplitude of these sampling signals ϕ_1 to ϕ_m is substantially equal to the amplitude (e.g. 0 to 5 V) of the digital data signal, which is the input signal to the sampling control circuit 4.

The sampling circuit 3 takes-in the brightness reference signal V_B with the timing of the sampling signal ϕ_1 to ϕ_m and outputs them as signal voltages V_{d1} to V_{dm}.

The amplitude of the brightness reference signal V_B is substantially equal to the amplitude of the voltage applied to the liquid crystal, which is -10V to 10V. It is usually greater than the amplitude of the sampling signals ϕ_1 to ϕ_m.

Fig. 6 shows the relation between the brightness reference signal V_B and the sampling signals ϕ_1 to ϕ_m at this time.

The brightness reference signal is a signal, whose voltage level varies stepwise from V_{B1} to V_{BK}. At this time the sampling signals ϕ_1 to ϕ_m are pulse phase signals, whose pulse width is t_ϕ and each of which is delayed by t_{PH} from the time t_0.

For example, for the sampling signals ϕ_1 to ϕ_m,at a timing indicated by 3 in Fig. 6 a voltage indicated by V_{B3} in the brightness reference signal V_B is selected and outputted as the signal voltage.

Fig. 7 shows another embodiment of the sampling signals ϕ_1 to ϕ_m. In this case the sampling signals ϕ_1 to ϕ_m are pulse width signals, whose pulse width t_{PH} varies. For example, at the timing indicated by 3 the voltage V_{B3} is outputted as the signal voltage similarly to that indicated in Fig. 6.

The sampling signals ϕ_1 to ϕ_m indicated in Figs. 6 and 7 changes the pulse phase as indicated in Fig. 6 or the pulse width as indicated in Fig. 7, responding to the data signal DATA inputted in the sampling control circuit 4.

The brightness reference signal V_B is not restricted to the signals indicated in Figs. 6 and 7, but it may vary e.g. linearly (a) or non-linearly, as indicated in Fig. 8.

Further the pulse phase times t_{PH} of the sampling signals ϕ_1 to ϕ_m may be distributed not necessarily with a constant interval. This is true also for the pulse width.

Fig. 19 shows a concrete example of the scanning circuit 2 indicated in Fig. 4. The scanning circuit consists of a shift register 40 and an output circuit 41. The shift register 40 generates successively scanning pulse signals S_1 to S_m.

On the other hand the output circuit 41 consisting of one-out-of-two multiplexers 41a to 41c selects either one of voltages V_{GH} and V_{GL}, responding to the scanning pulse signals S_1 to S_n. The TFTs 1a are turned-on by the V_{GH} stated above and turned-off by the V_{GL}. Fig. 20 indicates the timing chart showing the operation of this scanning circuit.

The scanning circuit may generate a voltage capable of turning-on the TFTs 1a for every line and it is not restricted to Figs. 19 and 20.

Fig. 21 shows an embodiment of the sampling control circuit 4 acting as digital-time function transforming means indicated in Fig. 4. The sampling control circuit 4 generates the sampling signals ϕ_1 to ϕ_m, which are time function signals for sampling the brightness reference signal V_B, whose voltage varies with the lapse of time, as explained, referring to Fig. 5. Consequently the sampling control circuit 4 outputs the pulse phase or the pulse width corresponding to the gray scale information of the digital data signal DATA.

In another embodiment of the sampling control circuit indicated in Fig. 21 the pulse phase can vary, depending to the gray scale of the data signal DATA and the number of gray scale is 4.

The operation of various parts will be explained below, referring to the timing charts indicated in Figs. 22 and 23. The data signal DATA is a digital signal including the gray scale information, which is taken in each of latch circuits 44 with the timing of the latch signals S_1 to S_m coming from a latch control circuit 42. Further, when the data signal for one line is taken in the group of latch circuits 43, then a group of registers 45 takes the data signal for one line all at once with the timing of a strobe signal STB.

On the other hand reference numeral 49 represents a binary counter dividing the frequency by 4, which is set by the strobe signal STB and counts-up clock signals CPC. Consequently the output signals DC0 (least significant bit) and DC1 (most significant bit) vary from DC0 = 0 and DC1 = 0 to DC0 = 1 and DC1 = 1.

A comparator compares the output signal DL0 (least significant bit) with the DL1 (most significant bit) of the register as well as the output DC0 with DC1 of the counter 49 and when they are in accordance with each other, a sampling signal ϕ is outputted.

At this time the sampling signal ϕ is either one of ϕ_A to ϕ_D having different phases, depending on the content of the output signals DC0 and DC1 of the register 46.

On the other hand the brightness reference signal V_B is obtained by A/D (analogue/digital transforming the output signals DC0 and DC1 of the counter 49. In this embodiment V_B has four levels from V_{B1} to V_{B4}.

For example, in the case where the output signals of the register 46 DC0 = 0 and DC1 = 1, the sampling signal is ϕ_C. As the result the output

voltage V_d of the sampling circuit 3 indicated in Fig. 4 is V_{B3}. In this way voltages of four different levels are outputted by the sampling circuit 3, depending on the state of the output signal of the register 46, i.e. the content of the data signal DATA.

Although this embodiment has been explained for the case where the display device is driven with 4 gray scale, it is possible to vary the number of gray scale by varying the number of bits.

Further, as the data signal DATA indicated in Fig. 21, data (2 x K bits) for a plurality (= K) of pixels may be inputted. In this way the speed of the operation of the sampling control circuit 42 can be lowered.

Fig. 27 shows another embodiment of the sampling control circuit 4. The registers 46 and the group of registers 45 are identical to those indicated in Fig. 21 and the number of gray scale is set to 4.

The circuit consists of decoders 70a, 70b, a reference pulse generating circuit 71, and electronic switches 72a to 73d. The operation of these parts will be explained, referring to Figs. 28, 29 and 30.

The reference pulse generating circuit 71 generates pulses CA to CD having different pulse phases, as indicated in Fig. 28, or those having different pulse widths, as indicated in Fig. 29.

On the other hand, as indicated in Fig. 30, when the data signals (DL0, DL1) of 2 bits from the register 46 are inputted in a decoder 70a, either one of G1 to G4 becomes H, depending on the content thereof.

Further, when the output signals G1 to G4 of the decoder 70a are turned to H, the electronic switches 72a to 73d are turned to the ON state, respectively.

Consequently either one of CA to CD indicated in Figs. 28 and 29 is selected depending on the content of the decoder signals DL0 and DL1 of the decoders 70a, 70b.

For example, in the case of the timing chart indicated in Fig. 29, for DL0 = L and DL1 = L CA is selected, which serves as the sampling signal. For DL0 = H and DL1 = L CB is selected; for DL0 = L and DL1 = H CC is selected; and for DL0 = H and DL1 = H CD is selected.

Fig. 31 shows still another embodiment of the sampling control circuit, where the number of gray scale is 4.

The decoder 79 decodes the data signal DATA of 2 bits including gray scale information to transform it into a signal of 4 bits d1 to d4. Signals thus obtained are inputted in capacitors 76 for every block successively through a data sample circuit 75 with the timing of output signals SG_1 to SG_m of a horizontal pulse generating circuit 74.

At this time, when signals of one line are inputted in the capacitors 76, they are inputted in capacitors 81 with the timing of the strobe pulse STB.

On the other hand a reference signal generating circuit 80 generates signals CP1 to CP4, as indicated in Fig. 32. As the result a select circuit 78 outputs AND (product) signals of signals D1 to D4 accumulated in the capacitors 81 and the signals CP1 to CP4. For example, when the signal D3 is H, the signal ϕ_1 is H between t_2 and t_3.

In this way the phase of the signal ϕ_1 varies, depending on the state of the signals D1 to D4.

Fig. 9 shows the timing of the operation of the whole device. Scanning signals V_{g1} to V_{gn} are signals, which turn-on the TFTs are after another and which are generated with the timing of the FST and CKV signals.

The brightness reference signal V_B is indicated for the case where the number of gray scale is 2, i.e. the liquid crystal is turned either to the ON state or to the OFF state. Consequently V_B has 3 levels of V_C, V_C+V_D and V_C-V_D. V_C+V_D and V_C-V_D are obtained by using V_C as the reference and varying only V_D. This is because the polarity of the voltage applied to the liquid crystal is inverted for every frame in order to AC drive the liquid crystal.

Here, in the case where the liquid crystal should be switched-off, the sampling signals ϕ_1 to ϕ_m are changed to a signal ϕ_{off} and inversely, in the case where it should be switched-on, they are changed to a signal ϕ_{on}.

Fig. 10 shows the timing, in the case where the liquid crystal is turned to the OFF state, together with the voltage V_{LC} applied to the liquid crystal 1b. In this example, as shown at the right lower side in Fig. 10, the object is the TFT located at the left upper side of the TFT liquid crystal panel 1 indicated in Fig. 5.

The voltage V_{LC} applied to the liquid crystal becomes equal to V_C, depending on the timing of the sampling signal ϕ_1 and the brightness reference signal V_B. On the other hand, when the potential of the common electrode 1C of the TFT liquid crystal is set to V_C, the voltage applied to the two terminals of the liquid crystal 1b is 0 and therefore the liquid crystal is turned to the OFF state.

Fig. 11 shows the timing in the case where the liquid crystal is turned to the ON state. A voltage V_C+V_D or V_C-V_D is applied to the liquid crystal 1b by delaying the phase of the sampling signal ϕ_1. The liquid crystal is turned to the ON state by the potential difference between this voltage and the potential V_C of the common electrode 1c.

Fig. 12 shows the timing, in the case where the liquid crystal is controlled with 8 gray scales. At this time the brightness reference signal V_B is divided into 8 levels and the polarity of the applied

voltage is inverted for every frame.

One of the 8 levels, into which the brightness reference signal V_B is divided, is selected by controlling the phase time t_{PH} of the sampling signal ϕ_1 to be from 1 to 8 to obtain the signal voltage.

Fig. 13 illustrates another embodiment of the sampling circuit 3, which consists of electronic switches 8 to 10, capacitors 17 to 19 and buffer circuits 20 to 22.

Fig. 14 shows the timing chart in this case. Here explanation will be made by taking the case, where the liquid crystal is controlled with 8 gray scales, as an example. The brightness reference signal taken-in with the timing of the sampling signals ϕ_1 to ϕ_m is held in the capacitors 17 to 19 and supplied to the signal lines 14 to 16 through the buffer circuits 20 to 22, respectively.

The brightness reference V_B is sampled during a period of time of t_s and written in the liquid crystal 1b during a period of time of t_w.

Fig. 15 illustrates still another embodiment. The sampling circuit 3 consists of electronic switches 8 to 10, capacitors 23 to 25, electronic switches 26 to 28 and buffer circuits 20 to 22.

Fig. 16 shows the timing charts in this case. Here explanation will be made by taking the case, where the liquid crystal is controlled with 8 gray scales, as an example. The brightness reference signal taken-in with the timing of the sampling signals ϕ_1 to ϕ_m is held in the capacitors 29 to 31.

In this embodiment the sampling of the brightness reference signal V_B is terminated in a period of time t_s, but the signal voltages V_{d1} to V_{dm} vary at the same time independently of the timing of the sampling.

Fig. 17 shows another example of the timing chart. The brightness reference signal V_B is sampled during a scanning period t_L for one line and inputted in the capacitors 29 to 31 before the beginning of the scanning period for the succeeding line.

By this method the effective time of the signal voltages V_{d1} to V_{dm} is equal to t_L.

Further the sampling signals ϕ_1 to ϕ_m may be formed by the pulse width control method indicated in Fig. 7. In addition the brightness reference signal V_B may have the waveform indicated in Fig. 8.

The scanning circuits indicated in Figs. 5, 13 and 15 are constructed preferably by using shift registers.

On the other hand it is conceivable to construct the sampling control circuit 4 by various methods. Fig. 18 illustrates another embodiment.

The sampling control circuit 4 is composed of latch circuits 33 and electronic switches 34. The display signals D_1 to D_k are inputted in the latch circuits 33.

On the other hand the sampling signals ψ_1 to ψ_k are inputted in the electronic switches 34 and one of them is selected, depending on the output of the latch circuits 33.

Further the scanning circuit, the sampling control circuit and the sampling circuit indicated in Fig. 5, 13 or 15 may be constructed in one body with the TFT liquid crystal panel. They are constructed preferably specifically with a P-Si TFT.

Fig. 24 illustrates an embodiment for the color display drive. In this embodiment the vertical color stripe display is shown, in which color filters of R (red), G (green) and B (blue) are arranged in the vertical direction. For this reason sampling control circuits are disposed separately for different colors. Each of the sampling control circuits 50 to 52 has the same construction as that indicated in Fig. 21.

Further the sampling circuit 3 may be disposed separately for different colors.

Fig. 25 illustrates another embodiment for the color display drive. In this embodiment there is disposed only one sampling control circuit 53. The data signals to the sampling control circuit 53 are switched by a color selector 54 to take-in the data signals for different colors of R, G and B separately.

Fig. 26 is a scheme illustrating an embodiment of the display system. Data signals to be displayed, corresponding at least to one image, are stored in a frame memory 62. These are read-out by an address signal coming from the control circuit 5 and transmitted to the sampling control circuit 4.

In the frame memory 62 are inputted data signals to be displayed coming from a microprocessor 56, a communication line 58 and each parts of a control circuit 57, a video circuit 59, a general use data input portion 60 and a memory 61 and inversely they can be also outputted therefrom.

The communication line 58 may be a line either in a wire system such as a telephonic network, etc. or in a wireless system such as a video text broadcast, POS, etc. The video circuit 59 executes processings such as transformation of analogue image signals as those for the TV broadcast, etc. into digital signals. Further the general use data input portion 60 is provided with a keyboard, through which letters, numerals, etc. are inputted, an input touch keyboard e.g. of menu type, etc. In addition the memory 61 may be either one of magnetic, optical, semiconductor memory devices, etc.

In an example of application of such a display device data inputted in the general use data input portion 60 may be edited on the display screen, or combined with image information coming from the video circuit 59 and stored in the memory frame 61. Information thus obtained may be transmitted

also to a distant location through the communication line 58.

By this embodiment it is possible to effect three operations of monitoring, edition and transmission (in/output) of information and in this way to construct a system, which is very useful to the mass communication society.

Although the object was a liquid crystal active matrix display in the embodiment described above, the application of this invention is not restricted thereto, it can be applied as well to the driving circuit of the signal circuit for a light emitting type display, whose brightness can be controlled by the amplitude in voltage, such as an electroluminescence (EL), a plasma display (PDP), etc. The embodiment indicated in Fig. 15 can be applied for the construction of the driving circuit in this case.

According to this invention it is possible to simplify the output circuit in the driving circuit and further to lower the speed of the operation of the circuit. In this way it becomes easy to construct the driving circuit by using ICs.

Claims

1. A gray scale display device comprising:
a display panel (1) including a plurality of scanning electrodes, a plurality of signal electrodes intersecting the plurality of scanning electrodes, a plurality of switching elements (1a) respectively formed at positions corresponding to intersections of scanning electrodes and the plurality of signal electrodes, and a plurality of display bodies, one display body connected to each switching element, each switching element responsive to a signal on the scanning electrodes of the corresponding intersection for applying a signal voltage from the signal electrode of the corresponding intersection to the corresponding display body, each display body responsive to the applied signal voltage for exhibiting a brightness controlled by the amplitude of the applied signal voltage;
digital signal generating means for generating digital signals including gray scale information;
holding means (33, 45) for temporarily holding digital signals including gray scale information inputted in a unit of a predetermined number of bits and corresponding at least to the plurality of signal electrodes;
digital-time function transforming means (4) for transforming the digital signals from the holding means into time function signals (o) for each signal electrodes;
means for providing a brightness reference signal;
time function-gray scale transforming means (3) for sampling the brightness reference signal, responding to the time function signal (o), and generating gray scale signals based on the brightness reference signal at the times of the time function signals (o);
storage means for holding the generated gray scale signals; and
scanning voltage generating means (2) for generating a scanning voltage for successively scanning the plurality of scanning electrodes;
characterized in that
said gray scale display device is a liquid crystal gray scale display device, said switching elements (1a) are thin film transistors, and in that strobe means are provided for simultaneously applying the held gray scale signals as signal voltage to each of the signal electrodes every scanning period.

2. A gray scale display device according to claim 1,
characterized in that
display bodies are liquid crystal display bodies.

3. A gray scale display device according to at least one of claims 1 or 2,
characterized in that
the digital-time function transforming means transforms the digital signals into time function signals of a voltage amplitude substantially equal to the voltage amplitude of the digital signals and the brightness reference signals providing means provides a brightness reference signal having a voltage amplitude greater than that of the digital signals and that of the time function signals.

4. A gray scale display device according to at least one of claims 1 to 3,
characterized in that
the digital signal generating means transforming analogue image signal into digital signals include gray scale information for each signal electrode.

5. A gray scale display device according to claim 1,
characterized in that
the digital signal generating means comprise a frame memory for storing digital signals including gray scale information for each signal electrode and corresponding at least one image.

6. A gray scale display device according to at least one of claims 1 to 5,
characterized in that

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also to a distant location through the communication line 58.

By this embodiment it is possible to effect three operations of monitoring, edition and transmission (in/output) of information and in this way to construct a system, which is very useful to the mass communication society.

Although the object was a liquid crystal active matrix display in the embodiment described above, the application of this invention is not restricted thereto, it can be applied as well to the driving circuit of the signal circuit for a light emitting type display, whose brightness can be controlled by the amplitude in voltage, such as an electroluminescence (EL), a plasma display (PDP), etc. The embodiment indicated in Fig. 15 can be applied for the construction of the driving circuit in this case.

According to this invention it is possible to simplify the output circuit in the driving circuit and further to lower the speed of the operation of the circuit. In this way it becomes easy to construct the driving circuit by using ICs.

Claims

1. A gray scale display device comprising:
a display panel (1) including a plurality of scanning electrodes, a plurality of signal electrodes intersecting the plurality of scanning electrodes, a plurality of switching elements (1a) respectively formed at positions corresponding to intersections of scanning electrodes and the plurality of signal electrodes, and a plurality of display bodies, one display body connected to each switching element, each switching element responsive to a signal on the scanning electrodes of the corresponding intersection for applying a signal voltage from the signal electrode of the corresponding intersection to the corresponding display body, each display body responsive to the applied signal voltage for exhibiting a brightness controlled by the amplitude of the applied signal voltage;
digital signal generating means for generating digital signals including gray scale information;
holding means (33, 45) for temporarily holding digital signals including gray scale information inputted in a unit of a predetermined number of bits and corresponding at least to the plurality of signal electrodes;
digital-time function transforming means (4) for transforming the digital signals from the holding means into time function signals (o) for each signal electrodes;
means for providing a brightness reference signal;
time function-gray scale transforming means (3) for sampling the brightness reference signal, responding to the time function signal (o), and generating gray scale signals based on the brightness reference signal at the times of the time function signals (o);
storage means for holding the generated gray scale signals; and
scanning voltage generating means (2) for generating a scanning voltage for successively scanning the plurality of scanning electrodes;
characterized in that
said gray scale display device is a liquid crystal gray scale display device, said switching elements (1a) are thin film transistors, and in that strobe means are provided for simultaneously applying the held gray scale signals as signal voltage to each of the signal electrodes every scanning period.

2. A gray scale display device according to claim 1,
characterized in that
display bodies are liquid crystal display bodies.

3. A gray scale display device according to at least one of claims 1 or 2,
characterized in that
the digital-time function transforming means transforms the digital signals into time function signals of a voltage amplitude substantially equal to the voltage amplitude of the digital signals and the brightness reference signals providing means provides a brightness reference signal having a voltage amplitude greater than that of the digital signals and that of the time function signals.

4. A gray scale display device according to at least one of claims 1 to 3,
characterized in that
the digital signal generating means transforming analogue image signal into digital signals include gray scale information for each signal electrode.

5. A gray scale display device according to claim 1,
characterized in that
the digital signal generating means comprise a frame memory for storing digital signals including gray scale information for each signal electrode and corresponding at least one image.

6. A gray scale display device according to at least one of claims 1 to 5,
characterized in that

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the digital-time function transforming means transforms the digital signals into pulse phase function signals.

7. A gray scale display device according to at least one of claims 1 to 6, characterized in that the digital-time function transforming means transforms the digital signals into pulse width time function signals.

8. A gray scale display device according to at least one of claims 1 to 7, characterized in that the brightness signal has a voltage, which varies with respect to time.

9. A gray scale display device according to at least one of claims 1 to 8, characterized in that the brightness reference signal providing means provides a brightness reference signal having a voltage which varies linearly with respect to time.

10. A gray scale display device according to at least one of claims 1 to 9, characterized in that the brightness reference signal providing means provides a brightness reference signal having a voltage which varies non-linearly with respect to time.

Patentansprüche

1. Graustufenanzeigevorrichtung, die umfaßt:
eine Anzeigetafel (1), die eine Vielzahl von Abtastelektroden umfaßt, wobei eine Vielzahl von Signalelektroden sich mit der Vielzahl von Abtastelektroden überschneiden und eine Vielzahl von Schaltelementen (1a) an Positionen gebildet sind, die den Schnittpunkten der Abtastelektroden und der Vielzahl von Signalelektroden entsprechen, und eine Vielzahl von Anzeigezellen, wobei eine Anzeigezelle mit jeweils einem Schaltelement verbunden ist und jedes Schaltelement auf ein Signal an den Abtastelektroden des entsprechenden Schnittpunktes für das Anlegen einer Signalspannung von der Signalelektrode des entsprechenden Schnittpunktes der entsprechenden Anzeigezelle reagiert, wobei jede Anzeigezelle auf die angelegte Signalspannung zur Erzeugung einer durch die Amplitude der angelegten Signalspannung gesteuerten Helligkeit reagiert;
digitale Signalerzeugungsvorrichtung für die Erzeugung von digitalen Signalen einschließlich Graustufeninformation;
Haltevorrichtung (33, 45) für das temporäre Halten digitaler Signale mit Graustufeninformation, die in einer Einheit einer vorgegebenen Zahl von Bits eingegeben wurden, und die wenigstens der Vielzahl von Signalelektroden entsprechen;
digitale Zeitfunktionsübertragungsvorrichtung (4) für die Übertragung der digitalen Signale von der Haltevorrichtung in Zeitfunktionssignale (o) für jede Signalelektrode;
Vorrichtung für die Erzeugung eines Helligkeitsreferenzsignals;
Zeitfunctions-Graustufenübertragungsvorrichtung (3) für die Abtastung des Helligkeitsreferenzsignals, die auf das Zeitfunktionssignal (o) reagiert und Graustufensignale aufgrund des Helligkeitsreferenzsignals zu den Zeiten der Zeitfunktionssignale (o) erzeugt;
Speichervorrichtung für das Halten der erzeugten Graustufensignale; und
Abtastspannungserzeugungsvorrichtung (2) für die Erzeugung einer Abtastspannung für das sukzessive Abtasten der Vielzahl von Abtastelektroden;
dadurch gekennzeichnet, daß
die besagte Graustufenanzeigevorrichtung eine Flüssigkristallgraustufenanzeigevorrichtung ist und die besagten Schaltelemente (1a) Dünnfilm-Transistoren sind, und daß Impulsvorrichtungen vorgesehen sind für das gleichzeitige Anlegen der gehaltenen Graustufensignale als Signalspannung an jede der Signalelektroden in jeder Abtastperiode.

2. Graustufenanzeigevorrichtung nach Anspruch 1,
dadurch gekennzeichnet, daß
die Anzeigezellen Flüssigkristallanzeigezellen sind.

3. Graustufenanzeigevorrichtung nach wenigstens einem der Ansprüche 1 oder 2,
dadurch gekennzeichnet, daß
die digitale Zeitfunktionsübertragungsvorrichtung die digitalen Signale in Zeitfunktionssignale einer Spannungsamplitude überträgt, die im wesentlichen gleich der Spannungsamplitude der digitalen Signale ist, und die die Helligkeitsreferenzsignale erzeugende Vorrichtung ein Helligkeitsreferenzsignal erzeugt mit einer Spannungsamplitude, die größer als die der digitalen Signale und der Zeitfunktionssignale ist.

4. Graustufenanzeigevorrichtung nach wenigstens einem der Ansprüche 1 bis 3,
dadurch gekennzeichnet, daß

die digitale Signalerzeugungsvorrichtung, die das analoge Bildsignal in digitale Signale überträgt, Graustufeninformation für jede Signalelektrode umfaßt.

5. Graustufenanzeigevorrichtung nach Anspruch 1,
dadurch gekennzeichnet, daß
die digitale Signalerzeugungsvorrichtung einen Bildspeicher für die Speicherung digitaler Signale mit Graustufeninformation für jede Signalelektrode und die wenigstens einem Bild entsprechen, umfaßt.

6. Graustufenanzeigevorrichtung nach wenigstens einem der Ansprüche 1 bis 5,
dadurch gekennzeichnet, daß
die digitale Zeitfunktionsübertragungsvorrichtung digitale Signale in Pulsphasenfunktionssignale überträgt.

7. Graustufenanzeigevorrichtung nach wenigstens einem der Ansprüche 1 bis 6,
dadurch gekennzeichnet, daß
die digitale Zeitfunktionsübertragungsvorrichtung die digitalen Signale in Pulsbreiten-Zeitfunktionssignale überträgt.

8. Graustufenanzeigevorrichtung nach Wenigstens einem der Ansprüche 1 bis 7,
dadurch gekennzeichnet, daß
das Helligkeitssignal eine Spannung hat, welche sich mit der Zeit ändert.

9. Graustufenanzeigevorrichtung nach wenigstens einem der Ansprüche 1 bis 8,
dadurch gekennzeichnet, daß
die das Helligkeitsreferenzsignal erzeugende Vorrichtung ein Helligkeitsreferenzsignal erzeugt, das eine Spannung hat, die sich linear mit der Zeit ändert.

10. Graustufenanzeigevorrichtung nach Wenigstens einem der Ansprüche 1 bis 9,
dadurch gekennzeichnet, daß
die das Helligkeitsreferenzsignal erzeugende Vorrichtung ein Helligkeitsreferenzsignal mit einer Spannung erzeugt, welche sich nicht linear mit der Zeit ändert.

Revendications

1. Dispositif d'affichage d'échelle de gris comprenant :
un panneau d'affichage (1) comprenant une pluralité d'électrodes de balayage, une pluralité d'électrodes de transmission de signaux qui recoupent la pluralité d'électrodes de balayage, une pluralité d'éléments de commutation (1a) formés respectivement dans des positions correspondant à des intersections d'électrodes de balayage et de la pluralité d'électrodes de transmission de signaux, et une pluralité de corps d'affichage, un corps d'affichage étant connecté à chaque élément de commutation, chaque élément de commutation étant apte à répondre à un signal appliqué aux électrodes de balayage de l'intersection correspondante pour l'application d'une tension de signal à partir de l'électrode de transmission de signaux de l'intersection correspondante au corps d'affichage correspondant, chaque corps d'affichage étant apte à répondre à la tension de signal appliquée pour produire une luminosité commandée par l'amplitude de la tension de signal appliquée;
des moyens de production de signaux numériques pour produire des signaux numériques incluant une information d'échelle de gris;
des moyens de maintien (33, 45) pour retenir temporairement des signaux numériques contenant une information d'échelle de gris et introduits dans une unité formée d'un nombre prédéterminé de bits et correspondant au moins à la pluralité d'électrodes de transmission de signaux;
des moyens (4) de transformation de signaux numériques en signaux de fonction temporelle pour transformer les signaux numériques provenant des moyens de maintien en des signaux de fonction temporelle (o) pour chacune des électrodes de transmission de signaux;
des moyens pour délivrer un signal de référence de luminosité;
des moyens (3) de transformation de fonction temporelle en échelle de gris pour échantillonner le signal de référence de luminosité, en réponse au signal de fonction temporelle (o) et produire des signaux d'échelle de gris sur la base du signal de référence de luminosité aux instants des signaux de fonction temporelle (o);
des moyens de mémoire pour conserver les signaux d'échelle de gris produits; et
des moyens (2) de production de tension de balayage pour produire une tension de balayage pour le balayage successif de la pluralité d'électrodes de balayage;
caractérisé en ce que
ledit dispositif d'affichage d'échelle de gris est un dispositif d'affichage d'échelle de gris à cristal liquide, lesdits éléments de commutation (1a) sont des transistors à couche mince, et en ce que des moyens d'échantillonnage sont prévus pour appliquer simultanément les signaux d'échelle de gris conservés, en tant

* C L M S *

que tension de signal à chacune des électrodes de transmission de signaux, lors de chaque période de balayage.

2. Dispositif d'affichage d'échelle de gris selon la revendication 1, caractérisé en ce que les corps d'affichage sont des corps d'affichage à cristal liquide.

3. Dispositif d'affichage d'échelle de gris selon au moins l'une des revendications, caractérisé en ce que les moyens de transformation de signaux numériques en signaux de fonction temporelle transforment les signaux numériques en des signaux de fonction temporelle possédant une amplitude de tension sensiblement égale à l'amplitude de tension des signaux numériques, et les moyens de délivrance de signaux de référence de luminosité délivrent un signal de référence de luminosité possédant une amplitude de tension supérieure a celle des signaux numériques et à celle des signaux de fonction temporelle.

4. Dispositif d'affichage d'échelle de gris selon au moins l'une des revendications 1 à 3, caractérisé en ce que les moyens de production de signaux numériques transformant un signal d'image analogique en des signaux numériques comprennent une information d'échelle de gris pour chaque électrode de transmission de signaux.

5. Dispositif d'affichage d'échelle de gris selon la revendication 1, caractérisé en ce que les moyens de production de signaux numériques comprennent une mémoire de trames servant à mémoriser des signaux numériques comprenant une information d'échelle de gris pour chaque électrode de transmission de signaux et correspondant à au moins une image.

6. Dispositif d'affichage d'échelle de gris selon au moins l'une des revendications 1 à 5, caractérisé en ce que les moyens de transformation de signaux numériques en signaux de fonction temporelle transforment les signaux numériques en des signaux de fonction de phase d'impulsion.

7. Dispositif d'affichage d'échelle de gris selon au moins l'une des revendications 1 à 6, caractérisé en ce que les moyens de transformation de signaux numériques en signaux de fonction temporelle transforment les signaux numériques en des signaux de fonction temporelle de durée d'impulsion.

8. Dispositif d'affichage d'échelle de gris selon au moins l'une des revendications 1 à 7, caractérisé en ce que le signal de luminosité possède une tension qui varie en fonction du temps.

9. Dispositif d'affichage d'échelle de gris selon au moins l'une des revendications 1 à 8, caractérisé en ce que les moyens de production du signal de référence de luminosité délivrent un signal de référence de luminosité ayant une tension qui varie linéairement dans le temps.

10. Dispositif d'affichage d'échelle de gris selon au moins l'une des revendications 1 à 9, caractérisé en ce que les moyens de production du signal de référence de luminosité fournissent un signal de référence de luminosité possédant une tension qui varie non linéairement dans le temps.