

PATENT SPECIFICATION

(11) 1 523 543

1 523 543

- (21) Application No. 15045/76 (22) Filed 13 April 1976
(31) Convention Application No. 50/049289
(32) Filed 23 April 1975 in
(33) Japan (JP)
(44) Complete Specification published 6 Sept. 1978
(51) INT CL² G09F 9/30 G02F 1/13
(52) Index at acceptance
G5C 342 350 372 373



(54) A LIQUID CRYSTAL DISPLAY DEVICE/DRIVING CIRCUIT ARRANGEMENT

(71) We, KABUSHIKI KAISHA SUWA SEIKOSHA, a Japanese body corporate of 3-4, 4-chome, Ginza, Chuo-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to liquid crystal display device/driving circuit arrangements, for example for digital electronic instruments such as measuring instruments or desk calculators.

The present invention seeks to improve the quality of the display produced by a liquid crystal display device, to simplify the construction of the driving circuit thereof, to lower the manufacturing costs and to improve reliability.

In recent years liquid crystal display devices have been used in a number of types of digital equipment because they have an advantageously low power consumption, may be miniaturized and are passive.

Up to now, conventional driving circuits for liquid crystal display devices have provided a static display either by retaining parallel display signals in a register for driving the display device for a given period, or by selecting, *via* a time-division signal, a short-term memory circuit corresponding to each digit of the display and causing said memory circuit to read a display signal, or by retaining display signals in series in a shift register for driving the display device directly for a given period.

It is, however, difficult to make the first two conventional driving circuits as large scaled integrated circuits (LSI) because the number of output terminals from the logic operation is large so that the number of input terminals of the circuitry for driving the display device using an alternating current is also large and the construction of the driving circuit as a whole is

complicated. Furthermore, the number of input terminals for the display device is increased because there must be as many input terminals as there are segments of the display device and wiring is complicated and manufacturing yield is apt to be low.

In the case of a driving circuit using a shift-register, because the signals used are series signals, the construction of the circuit is simplified and the mounting of a large scale integrated circuit is simplified. However, because the display signals are driven directly by the shift register, the period for transmission of the display signals cannot be ignored, where the display consists of a number of digits. When the frequency of the clock signal to the shift register is low, the transmission-period will be long and the transmission-period as a fraction of the display-period is high, so that the display clarity deteriorates and it appears to flicker. Moreover, because the display device is of the static type, the number of terminals of the display device corresponds to the number of segments. This is important from the point of view of manufacture.

According to the present invention there is provided a liquid crystal display device/driving circuit arrangement comprising: a liquid crystal display device consisting of a first set of electrodes and a second set of electrodes with liquid crystal material therebetween, each of the first and second sets of electrodes consisting of a plurality of groups of electrodes, the electrodes of each group being electrically connected together; and a driving circuit including shift register means having a plurality of stages for receiving serial display signals for driving the display device, and a memory circuit means for receiving in parallel and memorizing the output from each stage of the shift register means, each group of electrodes of the first set of electrodes being connected to one output of the memory means, so that, in operation, the display device is driven in

50

55

60

65

70

75

80

85

90

95

multiplex manner by means of the outputs of the memory means applied to the first set of electrodes and potential signals applied to the second set of electrodes.

5 Preferably the first set of electrodes are arranged in a plurality of digit formations to enable a respective plurality of digits to be displayed, the said groups of electrodes of the first set of electrodes comprising
10 corresponding segment, electrodes of adjacent pairs of digit formations. The second set of electrodes may comprise electrodes, each one being common to all segments in a respective digit formation.

15 The groups of electrodes of the second set of electrodes may consist of two groups of alternate common electrodes.

The arrangement may include an alternating current driving means. The driving means may be an exclusive OR gate.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:—

25 Figure 1 is a circuit diagram of a liquid crystal display device/driving circuit arrangement according to the present invention,

30 Figure 2 illustrates the voltage-contrast characteristics of a liquid crystal material of the liquid crystal display device/driving circuit arrangement of Figure 1,

35 Figure 3 consists of timing charts illustrating the operation of the liquid crystal display device/driving circuit arrangement of Figure 1, and

40 Figure 4 illustrates part of another embodiment of a liquid crystal display device/driving circuit arrangement according to the present invention.

Referring first to Figure 1 there is illustrated a liquid crystal display device/driving circuit arrangement according to the present invention having a store 1 for retaining setting-contents (input) and the result of operations (output) in the case of a desk calculator or analogue-digital converted contents, etc (input) in the case of a measuring instrument or time-contents in the case of a timepiece as BCD codes. The contents of the store 1, stored as a BCD code, are transmitted therefrom to a shift register 2 which holds 4 bits per digit to convert the contents of the store 1 into serial display signals. The serial-display signals from the shift register are transformed into display signals consisting of 7 segments per digit by a decoder circuit 3. The output from the decoder circuit 3 is introduced into a shift register 4 holding 8 bits, that is to say the data for one digit at a time. A signal for displaying a decimal point is applied to the shift register 4 from a terminal 5, the display device being
65 constituted so that each digit of the display

is formed with 8 segments one of which is a decimal point. A clock signal A is applied to the shift register 4 via a terminal A and delivers a number of pulses corresponding to the total number of segments; i.e. in one time period T_1 as shown by the timechart A of Figure 3, the signals required to cause a display of one word, i.e. all the digits, are transmitted as a series of pulses. This series of signals is introduced into an alternating current driving circuit 6 for a liquid crystal display device 7 which produces the display. The circuit 6 is constituted by an exclusive OR gate to transmit a lighting signal as an inversion signal and a non-lighting signal as a noninversion signal at intervals of 2 words upon receipt of an alternating current signal B applied to the terminal B (see time-chart B of Figure 3).

The display produced by the display device 7 consists of six digits, the data in total constituting one word and with the digit signals being made available to the shift register 16, 17, 18 with timings of $D_1, D_2, \dots D_6$. Until now, because the display signals were in parallel, it was necessary to provide a gate for driving each segment of the display device using alternating supply. However, in the above described embodiment of the present invention, as a series of signals is used to drive the display device, a single gate for the alternating supply signal B is sufficient.

The reason why the alternating supply signal B is inverted at intervals of 2 words is that a 2-phase dynamic driving of the liquid crystal display device is employed. To this end, the 2 digits of each adjacent pair are displayed alternately, the electrodes of the display device 7 being arranged as follows. A digit 8 has segments a_1 to h_1 which correspond to respective segments a_2 to h_2 of a digit 9; the same applies to digits 10 and 11 and digits 12 and 13. The segments ($a_1, b_1, c_1, d_1, e_1, f_1, g_1, h_1 \dots a_6, b_6, c_6, d_6, e_6, f_6, g_6, h_6$) are electrically connected in such a way that corresponding segments of pairs of adjacent digits, for example segments a_1, a_2 , constitute one group, segments b_1, b_2 , constitute a second group etc. A common electrode 14 is associated with alternate digits 8, 10, 12 and a common electrode 15 is associated with digits 9, 11 and 13. The display device therefore has first electrode groups constituted by the common electrodes 14, 15 and second electrode groups constituted by the segments a_1, a_2, b_1, b_2 , etc.

The operation of the embodiment of Figure 1 will be explained in more detail in conjunction with the time-charts of Figure 3. Digit signals D, E, are applied to the common electrode 14 and the common electrodes 15 respectively. The potential difference between the electrodes of a

segment may at any time have one of three voltage levels, namely 0, V_0 , $2V_0$, the level 0 and the level V_0 being such as to be insufficient to cause the display device 7 to generate a display i.e. below the threshold voltage of liquid crystal material in the display device, while the level $2V_0$ is being sufficient to cause the display 7 to generate the display. The applied voltage-contrast characteristics of a liquid crystal material of the display device 7 are illustrated in Figure 2.

As an example let it be assumed that segment a_1 of the digit 8 is to produce a display and the segment a_2 of the digit 9 is not to produce a display. A segment signal F (Figure 3) having a peak voltage of $2V_0$ is applied to the joint terminal F_1 at the end of time T_1 . The digit signal D, applied to the common electrode 14, during the time T_1 is at the level of $2V_0$ and segment a_1 is at level 0 so that the voltage between the segment a_1 and the electrode 14 is $+2V_0$ and the segment produces a display. At this time, the common electrode 15 of the segments a_2 is at level $+V_0$ (signal E) and segment a_2 is at level 0, the same as that of segment a_1 , so that the voltage between the segment a_2 and the common electrode 15 is $+V_0$ so that the segment a_2 does not produce a display. During the time period T_2 , the voltage level between the common electrode 14 and the segment a_1 is $-V_0$, and the voltage level between the common electrode 15 and the segment a_2 is 0 so that neither the segment a_1 nor the segment a_2 produces a display. During the time period T_3 , the voltage level between the common electrode 14 and the segment a_1 is $-V_0$ so that the segment a_1 produces a display and the voltage level between the common electrode 15 and the segment a_2 is $-V_0$ so that the segment a_2 does not produce a display. Thus the digits 8, 9 have an alternating square wave applied thereto regardless of whether they produce a display or not. Time-chart G shows the voltage between the common electrodes 14 and the segment a_1 and the time-chart H shows a voltage between the common electrode 15 and the segment a_2 . The net effect is that the display device 7 is driven by an alternating current thus prolonging the life of the liquid crystal material. The other segments of the digits 8, 9 and the digits 10, 11 and 12, 13 are driven in a similar manner to the digits 8, 9 so that a dynamic display is produced.

By employing a 2-phase dynamic AC driving of the display device 7, the display device is subject to multiplex driving, which is not conventional. Further, because the digits to be displayed are divided in such a way that two digits form one group, the register which stores the display signals from the circuit 6 is composed of shift

registers the number of which is half the number of digits. In the illustrated embodiment shift registers 16, 17, 18 each consisting of 8 bits per pair of digits apply the display signal from the circuit 6. Until now in the prior art in the case of a conventional liquid crystal display device/driving circuit arrangement using shift registers as the static display, a shift register had to be provided for each digit.

Memory circuits 19, 20, 21 correspond to shift registers 16, 17, 18 respectively. The memory circuits read, with the timing indicated by the timing-chart C, the display signals which are stored in the respective shift-registers and transmit them to the display device 7 through respective boosting circuits 22, 23, 24, so that the display device produces a display. If the display device 7 were driven in the conventional manner directly by the shift registers 16, 17, 18, without the memory circuits, 19, 20, 21, the segment signals, for example, would become the transmitted signals as shown by time-chart I in Figure 3, so that the display produced by the display device would flicker during the period T_4 , and the quality of the display would be inferior. The longer the period T_4 , which depends upon the number of digits, the more marked this flickering of the display would become. Similarly, flickering of the display would be marked if the clock frequency were reduced. Boosting circuits 22, 23, 24 produce the voltage $2V_0$ from the standard driving voltages V_0 supplied for example, by a battery.

As stated above, because the display is produced by way of the memory circuits which read the transmitted display signals at fixed instants, the display produced by the display device does not flicker and its quality is improved. A digit-selecting circuit 25 selects the digit corresponding to the digit signal (time-charts D and E). The order in which the digits are selected by the selecting circuit 25 is with the timings D_1 , D_3 , D_5 , and D_7 , D_4 , D_6 . That is to say digits 8, 10, 12 corresponding to timings D_1 , D_3 , D_5 respectively are displayed by the digit signal D, and digits 9, 11, 13 corresponding to timings D_2 , D_4 , D_6 respectively are displayed by the digit signal E. Gates 26, 27 select the display signal and the clock signal A and are controlled by the selecting circuit 25.

Figure 4 illustrates an alternative liquid crystal display device of a liquid crystal display device/driving circuit arrangement according to the present invention. The segment electrodes are indicated by V and each electrode consists of segments a_1 , b_1 , c_1 , d_1 , e_1 , f_1 , g_1 , h_1 and are arranged so that segments a_1 , b_1 , c_1 , h_1 constitute a group X_1 and segments d_1 , e_1 , f_1 , g_1 constitute a group

(10) (12)

4
5
10
Y₁. Similarly the other digits are each divided into two groups namely Y₂, X₂, and Y₃, X₃. A common electrode w is divided so that it has four parts Z₁, Z₂, Z₃, Z₄, namely a part Z₁ corresponding to the segments a and f of each digit, a part Z₂ corresponding to segments f and g of each digit, a part Z₃ corresponding to segments c and e of each digit and a part Z₄ corresponding to segments d and h of each segment.

15
The embodiment of Figure 4 is driven by a 4-phase dynamic driving method as described in British Patent Specification No. 1,370,489, the disclosure of which is incorporated herein by way of reference.

20
25
30
As mentioned above, in the described embodiments of the present invention by providing memory circuits between the display device and the shift registers and arranging the display signals in series, the quality of the display is improved, the display device is simplified and manufacturing costs are lowered especially using the 2-phase dynamic AC driving method. Moreover, the number of bits of the shift registers is reduced because the number of input terminals of the display device is reduced. Moreover, a single gate for the driving signal may be used so that the arrangement is simplified and it is easy to make the driving circuit as a large scale integrated circuit (LSI).

35
The present invention is suitable for use in digital electronic instruments, for example, electronic desk calculators, measuring instruments having digital displays and liquid crystal wrist-watches.

40
45
In the illustrated embodiment the display device displays 6 digits but the invention is not limited thereto. Furthermore, in the embodiment of Figure 1, the display is produced by a 2-phase-driving method but again the invention is not limited thereto. MOS transistor, flip-flop circuits may be used for the memory circuits. The arrangements and the connections of the segments also is not limited to the arrangements illustrated.

50
WHAT WE CLAIM IS:—

1. A liquid crystal display device/driving circuit arrangement comprising; a liquid crystal display device consisting of a first set

of electrodes and a second set of electrodes with liquid crystal material therebetween, each of the first and second sets of electrodes consisting of a plurality of groups of electrodes, the electrodes of each group being electrically connected together; and a driving circuit including shift register means having a plurality of stages for receiving serial display signals for driving the display device, and a memory circuit means for receiving in parallel and memorising the output from each stage of the shift register means, each group of electrodes of the first set of electrodes being connected to one output of the memory means, so that, in operation, the display device is driven in multiplex manner by means of the outputs of the memory means applied to the first set of electrodes and potential signals applied to the second set of electrodes.

2. An arrangement as claimed in Claim 1 in which the first set of electrodes are arranged in a plurality of digit formations to enable a respective plurality of digits to be displayed, the said groups of electrodes of the first set of electrodes comprising corresponding segment electrodes of pairs of adjacent digit formations.

3. An arrangement as claimed in Claim 2 in which the second set of electrodes comprises electrodes common to all segments in each digit formation.

4. An arrangement as claimed in Claim 3 in which the groups of electrodes of the second set of electrodes consist of two groups of alternate common electrodes.

5. An arrangement as claimed in any preceding claim including an alternating current driving means.

6. An arrangement as claimed in Claim 5 in which the driving means is an exclusive OR gate.

7. A liquid crystal display device/driving circuit arrangement substantially as herein described with reference to and as shown in the accompanying drawings.

J. MILLER & CO.,
Agents for the Applicants,
Chartered Patent Agents,
Lincoln House,
296—302 High Holborn,
London, WC1V 7JH.

(10) (12)



Y₁. Similarly the other digits are each divided into two groups namely Y₂, X₂, and Y₃, X₃. A common electrode w is divided so that it has four parts Z₁, Z₂, Z₃, Z₄, namely a part Z₁ corresponding to the segments a and f of each digit, a part Z₂ corresponding to segments f and g of each digit, a part Z₃ corresponding to segments c and e of each digit and a part Z₄ corresponding to segments d and h of each segment.

The embodiment of Figure 4 is driven by a 4-phase dynamic driving method as described in British Patent Specification No. 1,370,489, the disclosure of which is incorporated herein by way of reference.

As mentioned above, in the described embodiments of the present invention by providing memory circuits between the display device and the shift registers and arranging the display signals in series, the quality of the display is improved, the display device is simplified and manufacturing costs are lowered especially using the 2-phase dynamic AC driving method. Moreover, the number of bits of the shift registers is reduced because the number of input terminals of the display device is reduced. Moreover, a single gate for the driving signal may be used so that the arrangement is simplified and it is easy to make the driving circuit as a large scale integrated circuit (LSI).

The present invention is suitable for use in digital electronic instruments, for example, electronic desk calculators, measuring instruments having digital displays and liquid crystal wrist-watches.

In the illustrated embodiment the display device displays 6 digits but the invention is not limited thereto. Furthermore, in the embodiment of Figure 1, the display is produced by a 2-phase-driving method but again the invention is not limited thereto. MOS transistor, flip-flop circuits may be used for the memory circuits. The arrangements and the connections of the segments also is not limited to the arrangements illustrated.

WHAT WE CLAIM IS:—

1. A liquid crystal display device/driving circuit arrangement comprising; a liquid crystal display device consisting of a first set

of electrodes and a second set of electrodes with liquid crystal material therebetween, each of the first and second sets of electrodes consisting of a plurality of groups of electrodes, the electrodes of each group being electrically connected together; and a driving circuit including shift register means having a plurality of stages for receiving serial display signals for driving the display device, and a memory circuit means for receiving in parallel and memorising the output from each stage of the shift register means, each group of electrodes of the first set of electrodes being connected to one output of the memory means, so that, in operation, the display device is driven in multiplex manner by means of the outputs of the memory means applied to the first set of electrodes and potential signals applied to the second set of electrodes.

2. An arrangement as claimed in Claim 1 in which the first set of electrodes are arranged in a plurality of digit formations to enable a respective plurality of digits to be displayed, the said groups of electrodes of the first set of electrodes comprising corresponding segment electrodes of pairs of adjacent digit formations.

3. An arrangement as claimed in Claim 2 in which the second set of electrodes comprises electrodes common to all segments in each digit formation.

4. An arrangement as claimed in Claim 3 in which the groups of electrodes of the second set of electrodes consist of two groups of alternate common electrodes.

5. An arrangement as claimed in any preceding claim including an alternating current driving means.

6. An arrangement as claimed in Claim 5 in which the driving means is an exclusive OR gate.

7. A liquid crystal display device/driving circuit arrangement substantially as herein described with reference to and as shown in the accompanying drawings.

J. MILLER & CO.,
Agents for the Applicants,
Chartered Patent Agents,
Lincoln House,
296—302 High Holborn,
London, WC1V 7JH.