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MATRIX DISPLAY PANEL AND METHOD OF DRIVING THE SAME

This invention relates to matrix display panels and methods of driving the same.

Matrix display panels having driving electrodes arranged in both X and Y directions to form a matrix of picture elements are used for displaying letters, graphs, or other images. For example, in a liquid crystal matrix display panel there may be (n x m) picture elements constituted by n data lines and m scanning lines. Conventionally, the liquid crystal matrix display panel is driven by a multiplex driving method where one scanning line is selected and then data signals on the n data lines are written into the picture elements corresponding to the selected scanning line. The period of application of the data signal to one picture element is $1/m$ of the entire period (frame period), which is generally called "duty". In general, 100 scanning lines are required for displaying pictures or graphs.

According to one aspect of the present invention, there is provided a method of driving a matrix display panel having a plurality of data lines and scanning lines arranged to form a matrix of picture elements, the method comprising supplying a ~~composite~~ video signal to the data lines in synchronism with a scanning signal, prohibiting the supply of the ~~composite~~ video signal during or around a vertical blanking interval, and making the voltage level of the scanning signal substantially equal to the voltage on the data lines during the vertical blanking interval.

Preferably the method includes prohibiting the supply of the ~~composite~~ video signal during part of an effective display period.

According to another aspect of the present invention there is provided a method of driving a matrix display panel having a plurality of data lines and scanning lines arranged to form a matrix of picture elements, the method comprising supplying a ~~composite~~ video signal to the data lines in synchronism with a scanning signal, prohibiting the supply of the ~~composite~~ video signal during or around a vertical blanking interval, making the voltage level of the scanning signal substantially equal to the voltage on the data lines during the vertical blanking interval, and prohibiting the supply of the ~~composite~~ video signal during part of an effective display period, the voltage level on the scanning lines corresponding to the prohibition of the supply of the ~~composite~~ video signal during part of the effective display period being made substantially equal to the voltage on the data lines during the vertical blanking interval.

According to a further aspect of the present invention there is provided a matrix display panel having a plurality of data lines and scanning lines arranged to form a matrix of picture elements, means for supplying a ~~composite~~ video signal to the data lines in synchronism with the scanning signal, means for prohibiting the supply of the ~~composite~~ video signal during or around a vertical blanking interval, and means for making the voltage of the scanning signal substantially equal to the voltage on the data line during the vertical blanking interval.

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

Figure 1 illustrates schematically the constructions of a liquid crystal matrix display panel;

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Figure 2 shows the waveforms of video signals and scanning signals applied to a liquid crystal matrix display panel;

Figures 3 and 4 are timing charts of signals applied to the liquid crystal matrix display panel of Figure 1;

5 Figure 5 is a more detailed timing chart of signals applied to a liquid crystal matrix display panel by a method according to the present invention;

Figure 6 is a block diagram of circuitry for producing a video signal as shown in Figure 5;

10 Figure 7(a) is a circuit diagram of a generator for use with a method according to the present invention; and

Figure 7(b) is a timing chart illustrating the operation of the generator of Figure 7(a).

Figure 1 shows an arrangement of picture elements in a liquid
15 crystal matrix display panel. Data lines S1 to Sn are arranged in the row direction and scanning lines C1 to Cm are arranged in the column direction to form a (n x m) matrix of picture elements.

Figures 2(a) to 2(d) illustrate waveforms of signals applied to the picture elements. Scanning signals C1, C2, C3....Cm are
20 applied to the scanning lines C1, C2, C3....Cm, with a duty of 1/n. Further, when displaying images where gray scale contrast is needed, video signals S1.....Sn can be provided by modulating the width of driving pulses according to the gray scale as shown in Figure 2(d). In the case of a television signal, there are 525 scanning lines
25 in one frame, which is divided into an odd number field and an even

number field by interlacing 262.5 scanning lines in each field. When displaying a picture on the liquid crystal matrix display panel by applying such television signals the liquid crystal matrix display panel must be driven with a $1/262.25$ duty. Even by
5 reducing the resolution by half, the liquid crystal matrix display panel must be driven with a $1/131.25$ duty. However, such a high duty has the disadvantage that it is difficult for the liquid crystal matrix display panel to produce a display with sufficient contrast.

The following is a detailed description of the present
10 invention based on a composite video signal of the NTSC system. Figure 3 shows the waveforms of an inputted video signal, wherein waveform (a) is a vertical synchronising signal V-S, waveform (b) is a horizontal synchronising signal H-S, waveform (c) is an enlargement of the horizontal synchronising signal H-S, and waveform
15 (d) is a video signal V.S. In Figure 4 the horizontal synchronising signal (hereinafter referred to as a horizontal scanning signal) of Figure 3 is shown on an enlarged scale. 262.5 lines of this horizontal scanning signal constitute one field of $1/60$ seconds, viz. 16.667 msec. In a liquid crystal matrix display panel, half
20 the lines, that is, 131 lines are sufficient to recognise the video signal. For example, by removing every other line from the horizontal scanning signal the driving duty is reduced to $1/131$.

However, actually, 200 to 220 lines of the 262.5 lines of the horizontal scanning signal include almost all the video
25 information, while the remaining 60 to 40 lines of the horizontal

scanning signal are within the vertical blanking interval and do not include any video information. Therefore, for instance, when the video signals during the 20th to 240th lines of the horizontal scanning signal are supplied to the liquid crystal matrix display panel, the video signals in the 1st to 19th and 241st to 262nd lines of the horizontal scanning signal are prohibited or blocked. Accordingly, in this case, if a liquid crystal matrix display panel displays an image, with every other line of the horizontal scanning signal removed, 110 lines of the horizontal scanning signal are provided during an effective display period to drive the liquid crystal matrix display panel. Further, the rms voltage value of the liquid crystal matrix display panel during the vertical blanking interval is made zero by keeping the potential or voltage of the horizontal scanning signal equal to that of the vertical scanning signal. This results in an increase of the ratio of the rms voltage value applied to the liquid crystal matrix display panel and thereby display contrast is improved.

Even if some of the lines of the horizontal scanning signal in the effective display period are abridged, the quality of the display produced is not reduced and is undistorted. For example, if one line of the horizontal scanning signal is abridged per $\underline{r}$ lines of the horizontal scanning signal during the effective display period ($\underline{r} = 3$ in Figure 4) the number of lines of the horizontal scanning signal actually used in the effective display period is reduced by a factor of $r-1/r$. Therefore, the duty can be decreased

by an amount corresponding to the reduction of the number of lines of the horizontal scanning signal. Moreover, the potential of the video signal may be kept at the same level as the horizontal scanning signal during the effective scanning period. Thus, the ratio of rms voltage applied to the selected picture elements to that of the unselected picture elements can be increased. As a result, display contrast is further improved. Thus a high contrast display can be obtained whilst maintaining apparent resolution of the display.

In general, when a liquid crystal matrix display panel is driven by a generalised AC amplitude selective multiplexing method of the V-NV type, the ratio of the rms voltage value applied to selected picture elements to that applied to unselected picture elements, the ratio being an indication of contrast level, is given by:

$$\frac{V_{ON}}{V_{OFF}} = \sqrt{\frac{N^2 + D - 1}{(N-2)^2 + D - 1}} \dots (1)$$

wherein D is the number of lines of the horizontal scanning signal giving a duty of 1/D. D is 262.5 in the conventional liquid crystal matrix display panel. On the other hand, when M lines of the horizontal scanning signal are prohibited or blocked during a blocked period adjacent the vertical blanking interval, and one line of the horizontal scanning signal is abridged for every r lines of the horizontal scanning signal during an abridged period, ratio of rms voltage value applied to the selected picture elements to

that applied to the unselected picture elements may be expressed as:

$$\frac{V_{ON}}{V_{OFF}} = \frac{N^2 + (D - M - 1) \frac{(r - 1)}{r}}{(N-2)^2 + (D - M - 1) \frac{(r - 1)}{r}} \dots (2)$$

5 the rms value being 0 during the blocked period and the abridged period. Comparing equations (1) and (2) it is seen that the ratio of rms voltage values are greater than conventional. For example, when $N=10$, $D=262.5$, $M=60$ and $r=3$, the ratio of rms voltage value obtained from equation (1) is 1.111, whilst that obtained from
10 equation (2) is 1.182. Thus the contrast of the display is improved by a factor of two or three times compared to the conventional display.

Figures 5(a) to 5(g) illustrate driving waveforms of a method according to the present invention for driving a liquid crystal matrix
15 display panel. The driving waveforms (b) to (g) are shown based on the horizontal synchronising or scanning signal waveform (a). One image is formed of one frame comprising an odd number field and an even number field. It takes 1/60 second for one field. The horizontal scanning signal has 262.5 lines in one field, m
20 lines are included during a display period, p lines and q lines are included in the blocked period before and after a vertical blanking interval.

Moreover, one line of every r lines of the horizontal scanning signal is abridged in the abridged period from the m lines of the
25 horizontal scanning signal for the purpose of abridgement of

selection of picture elements. A plurality, m' , of scanning signals C_1 to $C_{m'}$ are applied to the scanning lines in order where $m' = \frac{r-1}{r} m$. Thus there is a period S to inhibit selection of picture elements of one line for every r lines of the horizontal scanning signal as shown in Figure 5.

Video signals S_1 to S_n are amplitude modulated. The amplitude of the video signal is $2V_0$ in an AC amplitude selected multiplexing method of $V_0 - NV_0$. The waveform of this video signal during the blocked period (lines p, q) is characterised by a fixed voltage level V_{NSO} in the odd number field or a fixed voltage level V_{NSE} in the even number field and is the same as the voltage level of unselected picture elements. Thus a voltage is not applied to the picture elements during the blocked period and thereby the rms voltage applied is prevented from increasing.

Simultaneously, the potential of the video signal is made equal to that of the horizontal scanning signal for each one line of every r lines of the horizontal scanning signal which is abridged. In other words, the potential of the video signal during the period S is V_{NSO} in the odd number field and V_{NSE} in the even number field.

A frame signal FL is a fundamental signal to cause AC inverting-drive liquid crystal matrix display panel on alternate fields.

Figure 6 is a block diagram of circuitry for generating the video signals S_1 to S_n associated with the waveforms of Figure 5. This circuitry consists of voltage selecting circuits 10 to 16.

The voltage selecting circuits 10 to 12 select V_{ONE} or V_{ONO} , V_{OFFE} or V_{OFFO} , and V_{NSE} or V_{NSO} respectively synchronised with the frame signal fL , and supply video signal voltage levels V_{ON} , V_{OFF} and voltage level V_N in the period S to the voltage selecting circuits 13, 14 respectively. The voltage selecting circuits 13, 14 generate video signals V'_{ON} , V'_{OFF} including V_{ON} , V_{OFF} in the effective display interval corresponding to lines m' and V_N in the blocked period corresponding to lines p , q , synchronised with a blocking period signal fD . In this way, the video signal having the waveform shown in Figure 5(f) is formed. The voltage selecting circuits 15, 16 deliver video signals V'_{ON} , V'_{OFF} to a data line Si synchronised with a display timing signal Di . A plurality n of blocks 17 each comprising the voltage selecting circuits 15, 16 are provided for supplying video signals $S1$ to S_n to n column electrodes.

Figure 7(a) is a circuit diagram of a generator for producing scanning signals $C1$ to C_m' when one line is abridged for every r lines of the horizontal scanning signal.

Figure 7(b) is a timing chart illustrating the operating of this generator. A clock pulse YCL is produced by omitting one of clock pulses $YCLO$ in a given period in synchronism with a blocking signal INH . A shift register 70 starts to operate by entering the clock pulse YCL and a start pulse YSP and delivers signal $Y1$, $Y2$, $Y3 \dots Y_m'$ to gates 71. These signals $Y1$, $Y2$, $Y3$, $\dots Y_m'$ are converted to signals $W1$, $W2$, $W3$, $\dots W_m'$ by the signal $\overline{INH}$ occurring



in the blocking period. The gates 71 supply the signals W1, W2, W3, ...Wm' to a driver 72. During the time between the signal W2 and the signal W3, the scanning signal cannot be applied to the driver 72. The driver 72 makes the selected level of the signal W1, W2, W3,...Wm' to be at a potential V_{SE} (during an even field) or V_{SO} (during an odd field) and the unselected picture elements to be at the level V_{NSE} or V_{NSO} . Thus the scanning signal C3 can be formed, for example, and delivered to the corresponding scanning line. The potential V_{NSE} , V_{NSO} of the scanning signals are made equal to that of the video scanning signal in the non-selecting picture elements so as not to apply an rms voltage to the picture element during the abridged period.

In the embodiment of the present invention described above a generalised AC amplitude selective multiplexing method of V-NV type is used to drive the liquid crystal matrix display panel. It will, however, be appreciated that the present invention is applicable to other driving methods such as driving methods using separate upper and lower electrodes of a liquid crystal matrix display panel, duplex scanning methods, quad-scanning methods for a duplex matrix display panel or a multi-matrix liquid crystal display panel.

Furthermore in the embodiment described above one line of every $\underline{x}$ lines of the horizontal scanning signal are abridged but this is not essential, improved contrast being obtained by merely prohibiting the supply of the video signal adjacent the vertical blanking interval. In this case equation (2) becomes:

$$\frac{V_{ONO}}{V_{OFFO}} = \sqrt{\frac{N^2 + D - M - 1}{(N-2)^2 + D - M - 1}} \quad \dots (3)$$



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when $N = 10$, $D = 131$ and $M = 30$, the ratio of rms voltage obtained from equation (1) is 1.089 whilst from equation (3) is 1.104.



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CLAIMS

1. A method of driving a matrix display panel having a plurality of data lines and scanning lines arranged to form a matrix of picture elements, the method comprising supplying a video signal to the data lines in synchronism with a scanning signal, prohibiting
5 the supply of the video signal during or around a vertical blanking interval, and making the voltage level of the scanning signal substantially equal to the voltage on the data lines during the vertical blanking interval.
2. A method as claimed in claim 1 including prohibiting the
10 supply of the video signal during part of an effective display period.
3. A method of driving a matrix display panel having a plurality of data lines and scanning lines arranged to form a matrix of picture elements, the method comprising supplying a video signal
15 to the data lines in synchronism with a scanning signal, prohibiting the supply of the video signal during or around a vertical blanking interval, making the voltage level of the scanning signal substantially equal to the voltage on the data lines during the vertical blanking interval, and prohibiting the supply of the video signal during
20 part of an effective display period, the voltage level on the scanning lines corresponding to the prohibition of the supply of the video signal during part of the effective display period being made substantially equal to the voltage on the data lines during the vertical blanking interval.



4. A method as claimed in claim 1 and substantially as herein described with reference to the drawings.
5. A matrix display panel having a plurality of data lines and scanning lines arranged to form a matrix of picture elements,
- 5 means for supplying a video signal to the data lines in synchronism with the scanning signal, means for prohibiting the supply of the video signal during or around a vertical blanking interval, and means for making the voltage of the scanning signal substantially equal to the voltage on the data line during the vertical blanking
- 10 interval.
6. A matrix display panel substantially as herein described with reference to and as shown in the accompanying drawings.