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LCD SYSTEM WITH A DUAL LCD SUBSYSTEM CONFIGURATION

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to an LCD (liquid crystal display) system for use in a battery powered electronic apparatus such as cellular telephones, radio pagers, etc. and more specifically to an LCD system with the power saving capability enhanced by having a dual LCD panel and respective electrode drivers.

2. Description of the Prior Art

One of most important features of battery powered electronic apparatus is to have a long battery life or to have a long interval between charging. For this purpose, every effort is made to reduce the electric power consumption of the apparatus, especially that of the LCD. For example, a reduced power consumption type LCD device is disclosed by Furuhashi et al. in Japanese unexamined patent publication No. Hei8-179,731 (1996). Furuhashi et al. reduced the LCD driving voltage to reduce the power consumption of a display system by simultaneously selecting a plurality of scanning electrodes of the LCD panel. However, if there is any data to be displayed in icon(s), driving operation is uniformly performed to the entire LCD panel regardless of whether data to be displayed in dot matrix as in other LCD system.

In many of battery powered systems, a part of the system is always operating in measuring time, waiting for or monitoring a specific radio wave, etc. even during the period of OFF state of the system. In such situations, it is often necessary to display the status of the system in the form of icon(s) or as one of very limited phrases. If there is no need of displaying other than icons and limited pattern of phrases, a dot matrix LCD is not necessary but a segment LCD is enough.

It is preferably an advantage of the invention to provide an LCD system with the power saving capability enhanced for use in a battery-powered apparatus.

SUMMARY OF THE INVENTION

A liquid crystal display (LCD) system of the invention is use in a battery-powered apparatus which includes a controller for controlling the apparatus. The LCD system comprises: an LCD panel comprising a first (icon display) LCD portion and a second (dot matrix) LCD portion electrically isolated from each other; a local power supply (voltage regulator) fed with a power supply voltage of the apparatus for supplying a first group of voltages and a second group of voltages; a first (icon display) controller/electrode driver cooperative with the first LCD portion and fed with the first group of voltages for displaying a predetermined pattern such as an icon associated with a received code on the first LCD portion; and a second (dot matrix) controller/electrode driver cooperative with the second LCD portion and fed with the second group of voltages for displaying an image in accordance with a received image data on the second LCD portion. The controller outputs the code and the image data. The controller is configured to output a dot display control signal (or a CD signal) to the local power supply to stop supplying the second group of voltages to the second controller/electrode driver, thereby reducing the power consumption.

BRIEF DESCRIPTION OF THE DRAWING

Further objects and advantages of the present invention will be apparent from the following description of the preferred embodiments of the invention as illustrated in the accompanying drawing, in which:

FIGs. 1A and 1B are schematic block diagrams showing examples of battery powered systems which can incorporate an embodiment of an LCD system according to the invention;

FIG. 2 is a schematic block diagram showing an illustrative embodiment of an LCD system according to the invention;

FIGs. 3 through 6 are flow charts of a group of subroutines which as a whole

control the operation of the switch circuits 231 (231a) and 232 (232a), i.e., a power-on interrupt subroutine 300, a dot matrix display subroutine 400, a display time out subroutine, and a power- off interrupt subroutine; and

FIGs. 7 through 9 are schematic block diagrams showing, in left halves, modifications of the first illustrative embodiment of FIG. 2.

Throughout the drawing, the same elements when shown in more than one figure are designated by the same reference numerals.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGs. 1A and 1B are schematic block diagrams each showing an example of battery powered apparatus which can incorporate an embodiment of an LCD system according to the invention. As shown in FIG. 1A, it is assumed that a battery powered electronic apparatus 100 comprises a power supply 110 containing a battery 111 for supplying a basic voltage ranging, e.g., from 3 through 5 volts in case of digital apparatus, components 2-1 which always needs power supply, components 2-2 which can be turned on and off by the user, and a manually controllable switch 120 connected between the power supply 110 and the components 2-2 which can be turned on and off. Since the voltages supplied to the components 2-1 and 2-2 are the same in value but different in path, the voltages supplied to the components 2-1 and 2-2 are discriminated by labels "V1" and "V2" (or "Pon").

A battery powered electronic apparatus 100a of FIG. 1B is identical to that of FIG. 1A except that the manually controllable switch 120 is inserted in the ground side of the components 2-2. In this case, the state of the switch 120 is detected at the ground terminals of the components 2-2.

Though not shown, an LCD system can be thought to be included in the components 2.

FIG. 2 is a schematic block diagram showing an illustrative embodiment of an

LCD system 20 according to the invention. In FIG. 2, the LCD system 20 comprises:

an LCD panel 200 which comprises an icon displaying LCD portion 201 and a dot matrix LCD portion 202 electrically isolated from each other and formed on a single common liquid crystal layer (not shown);

electrode drivers 211 for icon display and 212 for dot matrix display having the output lines thereof connected to the icon displaying LCD portion 201 and the dot matrix portion 202;

an icon display controller 211 having its output connected to the electrode driver 211;

a dot matrix display controller 222 provided with a video RAM (random assess memory) (not shown) and having its output connected to the electrode driver 212;

an electrode driver voltage regulator 240 for outputting electrode driver 211 voltage(s) and electrode driver 222 voltage;

a main controller 260, which is a well-known microcomputer comprising a not-shown CPU (central processing unit), a not-shown ROM (read only memory), and not-shown RAM (random access memory), for controlling the whole of the battery powered apparatus 100 (or 100a) as well as the LCD system;

an address 261 and a data 262 bus which interconnects the not-shown CPU, the icon display controller 221, the dot matrix display controller 222, and other components 2 of FIG. 1;

a switch circuit (SW) 231 inserted between the power supply line V1 and the icon display controller 221 power input and having its control input connected to a CI output of the controller 260;

a switch circuit 231a inserted between the voltage regulator 240 output VI and the electrode driver 211 voltage input and having its control input connected to the CI output of the controller 260;

a switch circuit (SW) 232 inserted between the power supply line V2 and the dot matrix display controller 222 power input and having its control input connected to a CD

output of the controller 260; and

a switch circuit 232a inserted between the voltage regulator 240 output VD and the electrode driver 212 voltage input and having its control input connected to the CD output of the controller 260.

It is noted that the electrode driver 211 and the icon display controller 221 may be of any type, and the electrode driver 212 and also the dot matrix display controller 222 may be of any type. The dot matrix display electrode driver 212 generally comprises a scanning electrode driver (not shown) and a data electrode driver (not shown) as is well known in the art.

The switch circuits 231 and 232 are of any electrically controllable type. Though the power supply lines VI and VD from the electrode driver voltage regulator 240 is shown as single lines, each of the voltage output VI and VD may comprise any desired number of output terminals in accordance with the ways of controlling and driving the LCD portions 201 and 202, respectively. Accordingly, each of the switch circuits 231a and 232a may comprises the same number of switch elements as that of the voltage regulator 240 VI and VD output terminals, respectively. All of the switch circuits 231 and 232 and the switch elements of the switch circuits 231a and 232a are configured to become conductive if respective control inputs supplied from the controller 260 outputs CI and CD are logical "1".

As seen from the foregoing, the elements 201, 211 and 221 and the elements 202, 212 and 222 constitute two independent LCD subsystems (i.e., an icon display LCD subsystem 270 and a dot display LCD subsystem 280) as shown in broken lines, and accordingly may be treated as such. Since the present invention imposes no restrictions on those elements, they are considered to be conventional, and won't be discussed any more. Also, the electrode driver voltage regulator 240 and the switch circuits 231, 231a, 232 and 232a constitute an LCD supply power circuit 250 as also shown as a broken line block. That is, the LCD system 20 comprises a controller 260, two LCD subsystems 270

and 280, and a LCD power supply circuit 250 which is capable of independently controlling the supplies of respective groups of voltages, (V1, VI) and (V2, VD), in response to the control signals CI and CD, respectively.

A signal V2 or /Pon indicative of the state of the manually controllable switch 120 is supplied to the main controller 260 as shown in FIG. 2. If the signal V2 or /Pon is logical "1", this means the ON state of the switch 120. Otherwise, the switch is OFF. In this specific illustrative embodiment, it is assumed that the main controller 260 is so configured that each change of the signal V2 or /Pon is given as an interrupt to the CPU (not shown).

Referring now to FIGs. 3 through 6, control operations performed by the main controller 260 (more precisely, by the above mentioned not-shown CPU under the control of subroutines stored in the ROM (not shown)) will be described in the following.

FIG. 3 shows an exemplary operation of a power-on subroutine invoked when the switch 120 is turned on. In this illustrative embodiment, it is assumed that the LCD system 20 is configured to display information on the icon display LCD portion 201. In order to know whether the icon display LCD 201 is operating, the controller 260 (hereinafter, referred to as "the CPU") makes a test to see if a CI flag which retains the state of the CI control signal of the controller 260 in step 301.

If so, which means that necessary voltages have been being supplied to the icon display LCD 201, then in step 302 the controller 260: makes the control signal CD logical "1" to cause the switch circuits 232 and 232a to become conductive thereby supplying necessary voltages V2 and VD to the dot matrix display controller 222 and the electrode driver 212; sets, to logical "1", a CD flag (not shown) which retains the state of the control signal CD; and starts a display timer which keeps a predetermined limit time which power supplying to the dot matrix display subsystem 280 (or 202, 212 and 222) is to be stopped in case of no key input for a period of.

Otherwise (if the CI flag is 0 in step 301), then, before proceeding to step 302,

in step 303 the CPU: makes the CI control signal logical "1" to cause the switch circuits 231 and 231a to become conductive thereby supplying necessary voltages V1 and VI to the icon display subsystem 270 (or 201, 211 and 221); and sets, to logical "1", a CI flag (not shown) which retains the state of the control signal CI. After step 302, the CPU returns to a main program from which the power-on interrupt subroutine has been called.

Once the battery powered apparatus 100 (or 100a) is turned on, if any data is to be displayed in the dot display area, a dot matrix display subroutine of FIG. 4 will be called. In FIG. 4, the CPU makes a test to see if the CD flag is 1 in step 401. If so, the CPU displays the data on the dot matrix LCD 202 and restarts the display timer in step 402. Otherwise, before proceeding to step 402, in step 403 the CPU: makes the CD control signal logical "1" to cause the switch circuits 232 and 232a to become conductive thereby supplying necessary voltages V12 and VD to the dot matrix display subsystem 280; and sets, to logical "1", the CD flag (not shown). After step 402, the CPU returns to the main program.

If the user has not operated the apparatus 100 (or 100a) for a period of the predetermined limit time in a turned-on state of the apparatus, then a display time out subroutine of FIG. 5 is invoked. In step 501 of FIG. 5, the CPU: inverts the CD control signal to cause the switch circuits 232 and 232a to become nonconductive thereby stopping supplying the necessary voltages V12 and VD to the dot display subsystem 280; and inverts the CD flag (to logical "0"). Then, the CPU returns to the main program. Doing this effectively saves electric power.

FIG. 6 is a flow chart showing an exemplary operation of a power-off interrupt subroutine. If the main program is interrupted by an interrupt signal caused by the signal V2 or /Pon, the main program invokes the power-off interrupt subroutine. In FIG. 6, the CPU makes the CD control signal logical "0" to cause the switch circuits 232 and 232a to become nonconductive thereby stopping supplying the necessary voltages V12 and VD to the dot display subsystem 280 in step 601. In decision step 602, the CPU makes a test to

see if there are any data to be displayed on the icon display LCD 201. If not, then in step 606 the CPU: makes the CI control signal logical "0" to cause the switch circuits 231 and 231a to become nonconductive thereby stopping supplying the necessary voltages V1 and VI to the icon display subsystem 270; and sets the CI flag (not shown) to logical "0". After step 606, the CPU returns to the main program. If the test result is YES in decision step 602, then the CPU makes another test in decision step 603 to see if the CI flag is logical "1". If so, the CPU proceeds to step 605, there the CPU displays the data on the icon display LCD 201 and returns. Otherwise, before proceeding to step 605, the CPU proceeds to step 604, where the CPU: makes the CI control signal logical "1" to cause the switch circuits 231 and 231a to become conductive thereby supplying the necessary voltages V1 and VI to the icon display subsystem 270; and sets the CI flag (not shown) to logical "1".

According to the present invention, an ability of stopping the power supply to the dot display subsystem 280 when in need of using only the icon display LCD 201 enables an effective reduction in the power consumption.

Many widely different embodiments of the present invention may be constructed without departing from the spirit and scope of the present invention. Referring to FIGs. 7 through 9, some of such embodiments will be described in the following.

The above illustrative embodiment has enabled completely independent operations of the two LCD subsystems 270 and 280. However, there seems to be almost no need of using only the dot matrix LCD portion 202 but not the icon display LCD portion 201. For this reason, assuming that the use of the LCD 202 is permitted only during the use of the LCD 201, the LCD system 20 of FIG. 2 can be modified as shown in FIG. 7. In FIG. 7, the switch circuit 231a has been eliminated, the switch circuit 231 has been replaced with a switch circuit 235 whose output is also connected, in place of the power supply line V1, to the power input terminal of the electrode driver voltage

regulator 240 and accordingly whose current capacity has to be large enough to feed the icon display controller 221 and the regulator 240. The above described subroutines are again available to this case.

Though the illustrative embodiment has used a single voltage regulator 240, the embodiment may be provided with two separate electrode drover voltage regulators 241 and 242 as shown in FIG. 8. In this case, in addition to the modification described in just above paragraph, the switch circuit 232a is eliminated, the switch circuit 232 is replaced with a switch circuit 236 whose output is also connected to the power input terminal of the electrode driver voltage regulator 242 as . The current capacity of the switch circuit 236 is large enough to feed the dot matrix display controller 222 and the regulator 242. The above described subroutines are again available to this case.

If the icon display LCD portion 201 is never used as long as the manually controllable switch 120 is OFF, the LCD system 20 of FIG. 2 can be simplified by simply removing the switch circuits 231 and 231a (accordingly, control signal CI line is also unnecessary in this case) as shown in FIG. 9. In this arrangement, the CPU or the controller 260 does not have to perform any operations using the control signal CI.

The simplest form of embodiments of the invention is obtained by further removing the switch circuit 232 in FIG. 9. Even the simplest form can satisfactorily reduce the power consumption.

Therefore, it should be understood that the present invention is not limited to the specific embodiments described in the specification, except as defined in the appended claims.



WHAT IS CLAIMED IS:

1. A liquid crystal display (LCD) system for use in a battery-powered apparatus which includes a controller for controlling the apparatus, comprising:

an LCD panel comprising a first LCD portion and a second LCD portion electrically isolated from each other, said second LCD portion having a dot matrix structure;

means fed with a power supply voltage for supplying a first group of voltages and a second group of voltages;

first means cooperative with said first LCD portion and fed with said first group of voltages for displaying a predetermined pattern such as an icon associated with a received code on said first LCD portion;

second means cooperative with said second LCD portion and fed with said second group of voltages for displaying an image in accordance with a received image data on said second LCD portion; and

said controller outputting said code and said image data, said controller comprising:

means for outputting a dot display control signal (or a CD signal) to said supplying means to stop supplying said second group of voltages to said second means.

2. A system as defined in claim 1, wherein said means for outputting a CD signal comprises means for outputting said CD signal if there is no key input for a predetermined period of time.

3. A system as defined in claim 1, wherein said controller comprises:

means for outputting a icon display control signal (or a CI signal) to said supplying means to stop supplying said first group of voltages to said first means.