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Datasheet for the decision
of 8 April 2014

Case Number: T 1051/10 - 3.4.03
Application Number: 02781889.7
Publication Number: 1449193
IPC: G09G3/36

Language of the proceedings: EN

Title of invention:
LIQUID CRYSTAL DISPLAY AND DRIVING METHOD THEREOF

Applicant:
Samsung Display Co., Ltd.

Headword:

Relevant legal provisions:
EPC 1973 Art. 83

Keyword:
Sufficiency of disclosure - (no)

Decisions cited:

Catchword:
Case Number: T 1051/10 - 3.4.03

DECISION of Technical Board of Appeal 3.4.03 of 8 April 2014

Appellant: Samsung Display Co., Ltd. 
(Applicant) 95, Samsung 2 Ro 
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Decision under appeal: Decision of the Examining Division of the 
European Patent Office posted on 11 December 
2009 refusing European patent application No. 
02781889.7 pursuant to Article 97(2) EPC.

Composition of the Board:
Chairman: G. Eliasson
Members: R. Bekkering 
T. Bokor
Summary of Facts and Submissions

I. The appeal is against the refusal of application no. 02 781 889 for lack of clarity, Article 84 EPC, and lack of an inventive step, Article 56 EPC (main request), for added subject-matter, Article 123(2) EPC, and lack of clarity, Article 84 EPC (first auxiliary request), for lack of an inventive step, Article 56 EPC (second auxiliary request) and for lack of clarity, Article 84 EPC, and lack of an inventive step, Article 56 EPC (third auxiliary request).

II. A summons to oral proceedings was issued by the board, provided with an annex in which a provisional opinion of the board on the matter was given.

In particular, the appellant was informed that the application would not appear to disclose the invention in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art, contrary to the requirement of Article 83 EPC 1973.

III. At the oral proceedings before the board held on 8 April 2014, the appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of the following:

Main request:

Claims 1 to 9 according to the main request filed with the letter of 7 March 2014,

First auxiliary request:
Claims 1 to 9 according to the first auxiliary request filed with the letter of 7 March 2014,

Second auxiliary request:

Claims 1 to 9 according to the second auxiliary request filed with the letter of 7 March 2014.

IV. Claim 1 of the main request reads as follows:

"A liquid crystal display (LCD), comprising:

an LCD panel (100) comprising a plurality of gate lines (S₁-Sₙ) for transmitting scanning signals, a plurality of data lines (D₁-Dₘ) that are insulated from and that cross the gate lines for transmitting image signals, and a plurality of pixels that are formed in an area surrounded by the gate lines (S₁-Sₙ) and the data lines (D₁-Dₘ) and that are arranged as a matrix pattern and that have switching elements (110) connected to the gate lines and data lines;

a data gray signal modifier (400) for receiving gray signals (Gₙ) from a data gray signal source, and for outputting modification gray signals (Gₘ') by considering gray signals of present (Gₙ) and previous frames (Gₙ₋₁) according to one or more modification parameters;

wherein the one or more modification parameters are at least one of a temperature, an image quality selected by a user, and an environment of the LCD,

a gate driver (200) for sequentially supplying the scanning signals; and

a data driver (300) for changing the modification gray signals into corresponding data voltages and outputting the image signals,\"
a storage device including look-up tables (LUTs) storing compensation values to modify the data gray signal for the one or more modification parameters; and a sensor for measuring the present temperature of the LCD; characterized in that

the LUT is made of compensation values MSB 4-bits among 8-bit gray signals, wherein each compensation value within a LUT is represented by \( G_{ij} \), and wherein the value for \( y=4 \) representing said most significant bits MSB 4-bit of an 8-bit gray signal, the present frame gray signal \( G_n \) in a row of the LUT is expressed as

\[
G_n = (i-1) \times 2^{(8-y)},
\]

and the previous frame gray signal \( G_{n-1} \) of a column of the LUT is expressed as

\[
G_{n-1} = (j-1) \times 2^{(8-y)};
\]

wherein \( G_{ij} \) represents a cell which is located in the \( i \)-row and the \( j \)-column of the LUT, and in that the LCD further comprises a LUT selector (445) adapted to select a suitable LUT for performing a LUT conversion; and a LUT converter (446) modifies the compensation value \( G_{ij} \) of the selected LUT so as to produce a compensation value \( G_{ij}' \) corresponding to a present measured temperature that satisfies the following equation when the present measured temperature does not correspond to a predetermined temperature and the predetermined temperature of which the difference from the present temperature is the smallest among a plurality of the predetermined temperatures:

\[
G_{ij}' = G_{ij} + \alpha (G_{ij} - G_{ii}) + \beta (G_{ij} - G_{ii})^2 + \gamma (G_{ij} - G_{ii})^4 + \ldots
\]

where \( G_{ii} = (i-1) \times 2^{(8-y)} \), and \( \alpha, \beta \) and \( \gamma \) are modification coefficients for compensating the difference between the present measured temperature and the predetermined temperature of a certain point of the LCD, wherein \( \alpha > 1 \) when the present temperature is lower than the predetermined
temperature and $\alpha<1$ when the present temperature is higher than the predetermined temperature."

V. Claim 1 of the first auxiliary request corresponds to claim 1 of the main request, however, with the following characterising portion:

"characterized in that
the LUT is made of compensation values MSB 4-bits among 8-bit gray signals, wherein each compensation value within a LUT is represented by $G_{ij}$, and wherein the value for $y=4$ representing said most significant bits MSB 4-bit of an 8-bit gray signal, the present frame gray signal $G_n$ in a row of the LUT is expressed as
$G_n=(i-1)\times2^{(8-y)}$, and the previous frame gray signal $G_{n-1}$ of a column of the LUT is expressed as $G_{n-1}=(j-1)\times2^{(8-y)}$; wherein $G_{ij}$ represents a cell which is located in the i-row and the j-column of the LUT; and wherein the data gray signal modifier (400) comprises:
a frame storage device for receiving the gray signals from the data gray signal source, storing the gray signals for a period of one frame, and outputting the same;
a controller (430) for controlling writing and reading the gray signals of the frame storage device; and
a data gray signal converter (440) for considering the gray signals of a present frame transmitted by the data gray signal source and the gray signals of a previous frame transmitted by the frame storage device, and outputting the modification gray signals, and wherein a clock signal frequency synchronized with the gray signal provided by the data gray signal source is different from that synchronized with the controller (430)."
VI. Claim 1 of the second auxiliary request reads as follows:

"A liquid crystal display (LCD), comprising: an LCD panel (100) comprising a plurality of gate lines ($S_1$-$S_n$) for transmitting scanning signals, a plurality of data lines ($D_1$-$D_m$) that are insulated from and that cross the gate lines for transmitting image signals, and a plurality of pixels that are formed in an area surrounded by the gate lines ($S_1$-$S_n$) and the data lines ($D_1$-$D_m$) and that are arranged as a matrix pattern and that have switching elements (110) connected to the gate lines and data lines; a data gray signal modifier (400) for receiving gray signals ($G_n$) from a data gray signal source, and for outputting modification gray signals ($G_m'$) by considering gray signals of present ($G_n$) and previous frames ($G_{n-1}$) according to a modification parameter, wherein the modification parameter is a temperature; a gate driver (200) for sequentially supplying the scanning signals; and a data driver (300) for changing the modification gray signals into corresponding data voltages and outputting the image signals, a storage device including look-up tables (LUTs) storing compensation values to modify the data gray signal for predetermined temperatures; and a sensor for measuring the present temperature of the LCD; characterized in that the LUT is made of compensation values MSB 4-bits among 8-bit gray signals, wherein each compensation value within a LUT is represented by $G_{ij}$, and wherein the value for $y=4$ representing said most significant bits MSB 4-bit of an 8-bit gray signal, the present frame
gray signal $G_n$ in a row of the LUT is expressed as $G_n=(i-1) \times 2^{(8-y)}$, and the previous frame gray signal $G_{n-1}$ of a column of the LUT is expressed as $G_{n-1}=(j-1) \times 2^{(8-y)}$; wherein $G_{ij}$ represents a cell which is located in the $i$-row and the $j$-column of the LUT, and in that the LCD further comprises a LUT selector (445) adapted to select a suitable LUT for performing a LUT conversion; and a LUT converter (446) adapted to modify the compensation value $G_{ij}$ of the selected LUT so as to produce a compensation value $G_{ij}'$ corresponding to a present measured temperature that satisfies the following equation when the present measured temperature does not correspond to the predetermined temperature of the selected LUT and the predetermined temperature of which the difference from the present temperature is the smallest among a plurality of the predetermined temperatures:

$$G_{ij}'=G_{ij}+\alpha(G_{ij}-G_{ii})+\beta(G_{ij}-G_{ii})^2+\gamma(G_{ij}-G_{ii})^4+...$$

where $G_{ii}=(i-1) \times 2^{(8-y)}$, and

$\alpha$, $\beta$ and $\gamma$ are modification coefficients for compensating the difference between the present measured temperature and the predetermined temperature of a certain point of the LCD, wherein $\alpha>1$ when the present temperature is lower than the predetermined temperature and $\alpha<1$ when the present temperature is higher than the predetermined temperature."

VII. The appellant submitted in substance the following arguments relevant to this decision:

As well known in the art, it was conceivable that only the four most significant bits (MSB) of the gray level signal were taken into account and the four least significant bits (LSB) thereof were ignored if such an
approximation level was acceptable for a particular use. Accordingly, the look-up table (LUT) could be also reduced and did not include all possible values in the range of 0 to 255.

Moreover, there was no teaching in the application that the temperature compensated value of $G_{ij}$ had to be necessarily always positive. In the equation 11, there was certainly a number of cases which lead to a positive result and a number of cases which lead to a negative result (for instance when $\beta$ and $\gamma$ are 0 and $(1 + \alpha) G_{ij} < \alpha G_{ij}$). This would mean that a negative or reversed voltage was applicable.

Furthermore, concerning the question how the temperature difference between the actual display temperature and the predetermined temperature for the LUT to be modified was taken into account, reference was made to the description (page 21, line 5).

Therefore, the requirements of Article 83 EPC were met.

**Reasons for the Decision**

1. The appeal is admissible.

2. **Main request**

2.1 **Sufficiency of disclosure**

2.1.1 As far as clear from the application, the look-up table (LUT) used provides compensated grayscale values $G_{ij}$ as a function of the grayscale value of the present frame
$G_n$ and the grayscale value of the previous frame $G_{n-1}$. The grayscale values in the table represent the four most significant bits of the 8-bit grayscale data used in the LCD panel (cf page 18, line 17 to page 24, line 21). An example of such a table is given in figure 6.

However, it remains unclear from the application as a whole how compensated grayscale values should be derived from the LUT for grayscale data of the present and previous frame not corresponding to any of the values of $G_n$ and $G_{n-1}$ provided in the table.

The appellant argued that the four least significant bits of the 8-bit grayscale data should be discarded. This would provide an acceptable approximation. Yet, as the grayscale data were modified to take account both of the previous frame grayscale data and of the actual temperature of the display, an image of better quality was achieved.

However, to the board this argument is not convincing.

First of all, at no point in the description is it stated that the least significant bits should be discarded.

Moreover, the starting point for the application is a known display with 8-bit grayscale data with modification of the grayscale data to take account of the previous frame grayscale data.

According to the application, the known display "generates a compensation data voltage by considering data voltages of present and previous frames, and provides the compensation data voltage to a data line of the LCD panel so that the pixel voltage becomes the
target level immediately, and thereby the response quality is enhanced. The compensation data voltage is determined according to a dynamic capacitance and a response speed of the liquid crystal. However, the dynamic capacitance and the response speed vary according to temperature. For example, when the temperature increases, the capacitance of liquid crystal decreases and the response speed of liquid crystal increases. Conversely, when the temperature decreases, the capacitance of the liquid crystal increases and the response speed decreases". The known display "compensates data voltage based on a predetermined compensation value with respect to a specific temperature, but parameters for setting the compensation value according to temperature vary as described above. Accordingly, over compensation occurs when a present temperature is higher than the specific temperature, and under compensation occurs when the present temperature is lower than the specific temperature, so correct data voltage compensation cannot be performed" (cf application, page 2, line 6 to page 3, line 4).

The object of the application is to overcome this deficiency. The application is, thus, concerned with further improving the image quality of what is already a high quality 8-bit grayscale image. Clearly, reducing the 8-bit grayscale data to only the four most significant bits to this end would not make sense as it rather would dramatically reduce the image quality and render the proposed subtle fine-tuning of the image quality by the more accurate temperature compensation irrelevant.

According to the description at one point, the remaining z least significant bits are modified by
calculation (cf page 22, lines 9 to 13). This calculation is, however, nowhere disclosed in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art.

According to the description at another point, a modification for the z least significant bits is made in a LUT (cf page 29, line 16 to page 30, line 6). This LUT is, however, nowhere explained in the application.

Accordingly, as essentially acknowledged by the appellant at the oral proceedings, the treatment of the least significant bits of the grayscale data remains unclear, so that the application is not considered to disclose the invention in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art, contrary to the requirement of Article 83 EPC 1973.

2.1.2 Furthermore, according to the application, in order to provide an accurate temperature compensation, a plurality of LUTs is provided for different predetermined temperatures. The LUT converter provides a modified LUT if the display temperature does not correspond to any of the predetermined temperatures. The modified LUT is produced based on the LUT of the closest predetermined temperature using the following equation:

\[ G_{ij}' = G_{ij} + \alpha (G_{ij} - G_{ii}) + \beta (G_{ij} - G_{ii})^2 + \gamma (G_{ij} - G_{ii})^4 + \ldots \]  (equation 11)

According to the description, "Such \( \alpha \), \( \beta \), and \( \gamma \) of each term of equation 11 are factors for compensating the difference between the present temperature and the predetermined temperature" (page 21, lines 4 to 15).
For example, according to the description, "when only the first term in equation 11 is used (that is, \( \beta = \gamma = \ldots = 0 \)), and if much compensation is required because the present temperature is lower than the predetermined temperature, the compensation is performed as \( \alpha > 1 \). If small compensation is reduced because the present temperature is higher than the predetermined temperature, the compensation is performed as \( \alpha < 1 \)" (cf page 21, line 20 to page 22, line 3).

However, for example, assuming that the actual display temperature is 20 °C and LUTs are provided for 0 °C, 25 °C and 40 °C as in the example on page 20, according to the application the LUT for 25 °C is to be modified using equation 11 above. With eg \( \beta = \gamma = \ldots = 0 \) and \( \alpha > 1 \) as suggested in the application (cf page 21, line 20 to page 22, line 3), for the exemplary compensation value \( G_{23} \) of page 20, lines 14 to 17 (ie a grayscale value of 16 for the present frame and a grayscale value of 32 for the previous frame (ie i=2, j=3 in the table of figure 6)), a negative compensation value \( G_{23}' \) is obtained:

\[
G_{23}' = G_{23} + \alpha (G_{23}-G_{22}) = 8 + \alpha (8-16) < 0.
\]

In fact, as can be easily verified, for parts of the table of figure 6 (ie where \( 1 + \alpha \) \( G_{ij} \) < \( \alpha G_{ii} \)) negative values for \( G_{ij}' \) are obtained.

In the board's opinion, however, grayscale data useable in the display of the application, which uses 8-bit grayscale data, should always be between 0 and 255.

The appellant argued that there was no teaching in the
application that the temperature compensated value of Gij had to be necessarily always positive. Negative values meant that a negative or reversed voltage was applicable.

However, negative grayscale values and the application, as a consequence, of negative or reversed voltage signals to the display, would be so uncommon that the application certainly would have mentioned if such values or signals were intended. In the absence of any indication in this respect in the application, the appellant's contention that negative compensation values would be acceptable is considered implausible.

Moreover, it remains unclear how the actual temperature, or the temperature difference between the actual temperature and the predetermined temperature for the LUT to be modified, is taken into account in the calculation of the temperature modified compensation values. In particular, the application is completely silent as to how the coefficients α, β, γ are calculated as functions of the temperature. Since the object of the invention is to take account of the actual temperature of the display in order to provide a better quality image, this aspect clearly is crucial in the present case. The appellant was not able to shed light on this issue either.

Hence, it must be concluded from the above that also the calculation of the temperature modified compensation values is not disclosed in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art.

2.1.3 Accordingly, the application does not disclose the invention in a manner sufficiently clear and complete
for it to be carried out by a person skilled in the art, contrary to the requirement of Article 83 EPC 1973.

The appellant's main request is, therefore, not allowable.

3. First auxiliary request

In claim 1 according to the first auxiliary request, the LUT converter providing the temperature modified LUT in claim 1 of the main request has been omitted.

However, as for the main request, the treatment of the least significant bits of the grayscale data in the determination of the modified grayscale data remains unclear. Accordingly, also for the first auxiliary request the requirement of Article 83 EPC 1973 is not met.

Hence, the appellant's first auxiliary request is not allowable either.

4. Second auxiliary request

Also for the second auxiliary request, for the same reasons given with respect to the main request, the determination of the modified grayscale data remains unclear.

Accordingly, also for the second auxiliary request the requirement of Article 83 EPC 1973 is not met.

The appellant's second auxiliary request is, therefore, not allowable either.
Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar:                      The Chairman:

S. Sánchez Chiquero                G. Eliasson

Decision electronically authenticated