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(54) **DISPLAY DEVICE AND METHOD OF OPERATION**

(57) A display device (10) has at least one light source for generating light to be viewed by a viewer. The display device (10) has a temperature sensor (38) for obtaining a measure of the temperature of the at least one light source. The display device (10) has at least one processor (30) which provides instructions to control operation of the at least one light source. The clock rate of

the processor (30) is controlled in dependence on the temperature of the at least one light source such that the processor (30) operates at a low clock rate when the temperature of the at least one light source is high and the processor (30) operates at a high clock rate when the temperature of the at least one light source is low.

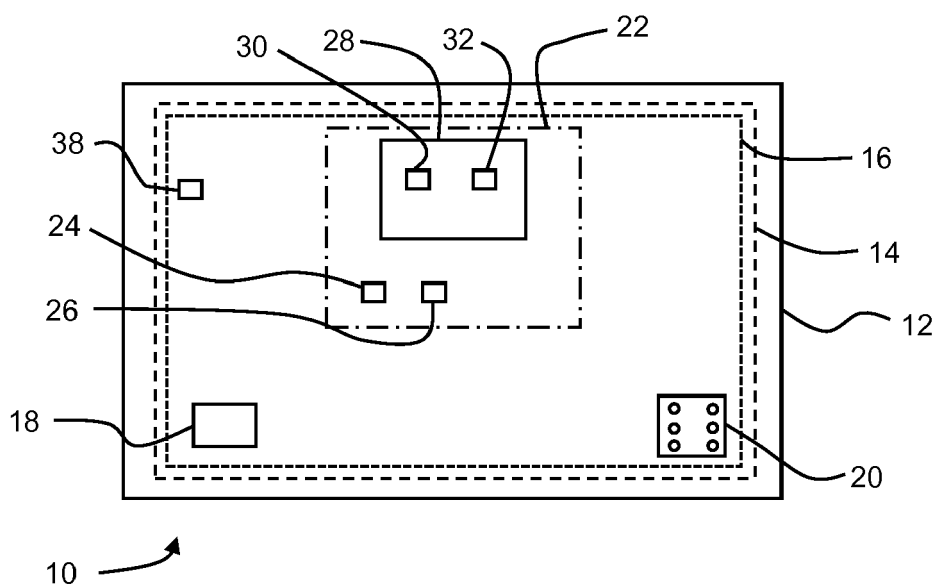


Fig. 1

DescriptionTechnical Field

5 **[0001]** The present disclosure relates to a display device and a method of operating a display device.

Background

10 **[0002]** Display devices are used widely in many different applications. Display devices have one or more light sources for generating light to be viewed by a viewer so that the viewer can see an image on the display device. Operation of the display device inevitably generates heat which can cause damage to components of the display device, including in particular to the one or more light sources. An option for lowering the temperature of the one or more light sources is to reduce the brightness or intensity of light which is output by the one or more light sources as this means that less electrical power (specifically less current, given that the voltage tends to be fixed) is required to drive the one or more
15 light sources. However, this may not always be acceptable to the viewer as this reduces the perceived quality of the image and, in some circumstances, can make it difficult to view the image.

Summary

20 **[0003]** According to a first aspect disclosed herein, there is provided a display device, the display device comprising:

at least one light source for generating light to be viewed by a viewer;
a temperature sensor for obtaining a measure of the temperature of the at least one light source; and
at least one processor constructed and arranged to provide instructions to control operation of the at least one light
25 source;
wherein the clock rate of the at least one processor is controlled in dependence on the temperature of the at least one light source such that the at least one processor is arranged to operate at a low clock rate when the temperature of the at least one light source is high and the at least one processor is arranged to operate at a high clock rate when the temperature of the at least one light source is low.

30 **[0004]** In an example, the processor is mounted on a plug-in module which can be plugged into and removed from the display device.

[0005] The module may be for example a plug-in module in accordance with at least one of the digital signage Open Pluggable Specification (OPS), OPS+ and Smart Display Module (SDM) by Intel.

35 **[0006]** In an example, the display device comprises:

a mainboard having a mainboard processor constructed and arranged to receive instructions for controlling operation of the at least one light source from the processor of the plug-in module and to pass instructions accordingly to the at least one light source. Alternatively or additionally, the processor of the plug-in module may pass instructions to the at least one light source directly, that is, not via a mainboard of the display device.

40 **[0007]** In an example, the mainboard processor is configured to receive temperature measurements for the at least one light source from the temperature sensor and to control the clock rate of the processor of the plug-in module in dependence on the temperature of the at least one light source.

[0008] In an example, the at least one processor is configured to control its clock rate to be at one of a plurality of values which corresponds to the temperature of the at least one light source being within a corresponding one of a plurality of ranges of predetermined temperatures.

45 **[0009]** This use of ranges for the temperature of the at least one light source and setting the clock rate of the processor to be at a corresponding clock rate for each range of temperatures has a number of advantages. First, the clock rate for the processor can be such that it always meets a minimum required value to ensure that the processor can process say video and/or audio correctly and appropriately. Secondly, it avoids rapid and frequent changes to the clock rate for the processor as the temperature of the at least one light source goes up and down over time.

50 **[0010]** In an example, the mainboard processor is configured to provide to said at least one processor an indication of the number of ranges of predetermined temperatures and an indication of the range in which the current temperature of the at least one light source falls, such that said at least one processor can determine its clock rate based on the number of ranges of predetermined temperatures and the indication of the range in which the current temperature of the at least one light source falls.

55 **[0011]** In an example, the display device comprises:

a display screen which comprises a plurality of display elements which are controllable to selectively pass light; and

a plurality of light sources, the light sources being arranged as a backlight for illuminating the display elements of the display screen, the temperature sensor being configured to obtain a measure of the temperature of the light sources by measuring the temperature of the backlight.

[0012] The light sources may be for example light-emitting diodes (LEDs). The display elements may be for example liquid crystal display (LCD) devices.

[0013] As an alternative, the display device may comprise a plurality of light sources, the light sources being operable to generate the pixels of an image. Such light sources may be for example organic light-emitting diodes (OLEDs) or micro LEDs.

[0014] According to a second aspect disclosed herein, there is provided a method of operating a display device, the display device comprising at least one light source for generating light to be viewed by a viewer, a temperature sensor for obtaining a measure of the temperature of the at least one light source, and at least one processor which provides instructions to control operation of the at least one light source, the method comprising:

obtaining a measure of the temperature of the at least one light source; and
controlling the clock rate of the at least one processor in dependence on the temperature of the at least one light source such that the at least one processor is arranged to operate at a low clock rate when the temperature of the at least one light source is high and the at least one processor is arranged to operate at a high clock rate when the temperature of the at least one light source is low.

[0015] In an example, the processor is mounted on a plug-in module which can be plugged into and removed from the display device.

[0016] In an example, the display device comprises a mainboard having a mainboard processor which receives instructions for controlling operation of the at least one light source from the processor of the plug-in module and to pass instructions accordingly to the at least one light source.

[0017] In an example, the mainboard processor receives temperature measurements for the at least one light source from the temperature sensor and controls the clock rate of the processor of the plug-in module in dependence on the temperature of the at least one light source.

[0018] In an example, the at least one processor controls its clock rate to be at one of a plurality of values which corresponds to the temperature of the at least one light source being within a corresponding one of a plurality of ranges of predetermined temperatures.

[0019] In an example, the mainboard processor provides to said at least one processor an indication of the number of ranges of predetermined temperatures and an indication of the range in which the current temperature of the at least one light source falls, and the at least one processor determines its clock rate based on the number of ranges of predetermined temperatures and the indication of the range in which the current temperature of the at least one light source falls.

[0020] In an example, the display device comprises:

a display screen which comprises a plurality of display elements which are controllable to selectively pass light; and
a plurality of light sources, the light sources being arranged as a backlight for illuminating the display elements of the display screen;
wherein the temperature sensor obtains a measure of temperature of the light sources by measuring the temperature of the backlight.

Brief Description of the Drawings

[0021] To assist understanding of the present disclosure and to show how embodiments may be put into effect, reference is made by way of example to the accompanying drawings in which:

Figure 1 shows schematically an example of a display device according to the present disclosure; and

Figure 2 shows schematically a block diagram of the main components of a display device according to the present disclosure.

Detailed Description

[0022] As noted, display devices are used widely in many different applications. Display devices have one or more light sources for generating light to be viewed by a viewer so that the viewer can see an image on the display device.

Operation of the display device inevitably generates heat which can cause damage to components of the display device, including in particular to the one or more light sources. An option for lowering the temperature of the one or more light sources is to reduce the brightness or intensity of light which is output by the one or more light sources as this means that less electrical power (specifically less current, given that the voltage tends to be fixed) is required to drive the one or more light sources. However, this may not always be acceptable to the viewer as this reduces the perceived quality of the image and, in some circumstances, can make it difficult to view the image.

[0023] In accordance with examples of the present disclosure, the clock rate (also called "clock speed" or operating frequency or the like) of a processor of a display device is controlled depending on the temperature of the at least one light source. The processor provides instructions to control operation of the at least one light source and receives temperature measurements for the at least one light source. If the temperature of the at least one light source is high, then the clock rate of the processor is lowered and vice versa.

[0024] The processor may be a processor on a mainboard of the display device. The mainboard of a display device is a circuit board having one or more processors, memory, etc., basically for controlling operation of the display device. The mainboard (which may also be referred to as a monitor board) is a fixed component in the sense that, during normal operation of the display device, the mainboard is never removed from the display device (though mainboards can usually be removed and replaced if for example a fault develops in a component of the mainboard). However, in other examples, the processor is a processor of a module that can be plugged into and removed from the display device. As will be discussed further below, such modules are commonly used in order to provide high processing power and a general computing ability for the display device, particularly but not exclusively for display devices used in so-called "signage" applications. In signage applications, the display device is typically used in a public area, for example at airports, railway stations, shopping centres, etc., for displaying advertisements or for information or entertainment that is of interest to a wide audience.

[0025] Referring now to Figure 1, an example of a display device 10 according to the present disclosure has a main housing 12 in which various components of the display device 10 are mounted. The display device 10 has a display screen 14 at which images are displayed. The images may be static and/or moving images.

[0026] The display device 10 may be of the type in which the display screen 14 has light sources which generate the pixels of the images directly, i.e. the light from a light source corresponds to the light required for that pixel and no backlight is required. The light sources may for example generate coloured light or may generate white light which is then passed through controllable coloured filters so as to achieve different colours in the image. Display devices that generate the pixels directly include for example display devices that use OLEDs (organic light emitting diodes), (inorganic) LEDs, including for example an LED display or "wall" or a micro LED display, and plasma technology.

[0027] Alternatively, the display device 10 may be of the type that has a backlight or backlight unit in which one or more light sources are mounted. The one or more light sources of the backlight emit light which is typically directed through a diffuser to the display screen 14. The diffuser helps to reduce glare that can otherwise occur. The display screen 14 in a display device 10 of this type is formed of or includes a number of display cells or elements (which are also often referred to as "pixels" as they typically correspond to pixels in the image that is displayed). The display cells or elements are controllable so as to selectively transmit from the one or more light sources or prevent light from the one or more light sources passing through the display screen 14. The display elements may be for example LCDs (liquid crystal display devices) or so-called "quantum dots". In a "direct-lit" backlight display device 10, the light sources are arranged typically in a regular array on a reflector panel behind the display screen 14. In an "edge-lit" backlight display device 10, there is at least one light source which is arranged at or towards an edge of the display device 10. Commonly, there are light sources arranged around each of the four edges of a display device 10 that has an edge-lit backlight. The light sources are typically elongate and may be for example cold-cathode fluorescent lamps. In other examples, the light sources located at the edges are plural LEDs or other individual light sources arranged along the edges of the display device 10. The light sources may emit light into a light guide which is mounted in front of a reflector. The light guide directs the light through a diffuser into the display screen 14.

[0028] The example illustrated schematically in Figure 1 is a display device 10 with a backlight 16. In this specific example, the backlight is a direct-lit backlight 16 though in other examples it may be an edge-lit backlight 16. In this example, the display screen 14 therefore has a plurality of display cells or elements which are controllable so as to selectively transmit from the one or more light sources of the backlight 16 or prevent light from the one or more light sources of the backlight 16 passing through the display screen 14. (The light sources provided by the backlight 16 are not shown in Figure 1 for reasons of clarity as they are arrayed across the plane of the backlight 16 in a direct-lit backlight 16 in practice.) Again though, in other examples, the display device 10 may be of the type that does not have a backlight and instead the light sources are in the display screen 14 and generate the pixels of the image directly.

[0029] The display device 10 has a power cable socket 18 for receiving an electrical power cable and a number of input and output sockets 20 for inputting and outputting video and audio and optionally control signals, etc., as is common in display devices.

[0030] The display device 10 of this example has a mainboard 22. The mainboard 22 has at least one processor 24,

memory 26, etc. configured to control the display device 10 and other functions, again as is common in display devices. In some examples of the present disclosure, the clock rate of the at least one processor 24 or clock rates of plural processors 24 may be controlled in dependence on the temperature of the light sources of the backlight 16.

[0031] However, in other examples, the display device 10 has a module 28 which is specifically arranged to be able to be plugged in and removed from the display device 10 as desired. The housing 12 of the display device 10 may have a slot (not shown) which can receive the module 28 to allow the module to be plugged into the display device 10 and make electrical connections to the mainboard 22. The module 28 has at least one processor 30, memory 32, etc. configured to control the display device 10 and other functions.

[0032] Discussing the use of the plug-in module 28 further, the processing power provided by the one or more processors 24 of a mainboard 22 provided with a display device 10 may be relatively low. Similarly, the onboard memory 26 (such as random access memory or RAM) may be of relatively low functionality or power and/or may have a relatively low clock speed and/or may be of relatively low capacity. However, the processing demands for display devices 10 continue to increase, so that for example the display device 10 can display high definition or high resolution images at increasingly higher resolutions over time. The display screen 14 itself may for example have a relatively long lifetime, of several years say. However, the demand or expectation for higher and higher resolution images can increase during that lifetime. Likewise, the demand or expectation for more sophisticated operation, such as displaying multiple video streams simultaneously, "picture-in-picture", interactivity with the screen, etc., also increases over time.

[0033] In view of this, such modules 28 are commonly used in order to provide high processing power and a general computing ability for the display device, as well as optionally wired and/or wireless network and/or Internet connections, etc. This is particularly but not exclusively the case for display devices 10 used in so-called "signage" applications. In signage applications, the display device is typically used in a public area, for example at airports, railway stations, shopping centres, etc., for displaying advertisements or for information or entertainment that is of interest to a wide audience.

[0034] The or each processor 30 of the module 28 may therefore be of relatively high processing power, and typically of much higher processing power than the processor(s) 24 provided on the mainboard 22 by default by the manufacturer of the display device 10. Similarly, the onboard memory 32 (such as random access memory or RAM) may be of relatively high power or functionality (such as a more powerful DDR (double data rate) type, such as DDR3 or DDR4 whereas the memory 26 of a mainboard may be only DDR2) and/or may have a relatively high capacity and/or may have a relatively high clock speed, and is typically more powerful than the memory 26 provided on the mainboard 22 by default by the manufacturer of the display device 10. Users or installers of the display device 10 can update or upgrade the effective processing power of the display device 10 simply by plugging in a module 28 of this type, and over time can swap out an existing module 28 and replace it with a module 28 with a higher processing power as needed.

[0035] The module 28 may be for example a plug-in module in accordance with at least one of the digital signage Open Pluggable Specification (OPS), OPS+ and Smart Display Module (SDM) by Intel. As is known, such modules 28 add computing capability to display devices and generally provide greater processing capability. Such modules 28 currently often have processors 30 that are based on the Intel X86 architecture.

[0036] Referring to Figure 2, this shows schematically a block diagram of the main components of the display device 10 in the case that the display device 10 has a plug-in module 28. The figure shows the display screen 14, the mainboard 22 and plug-in module 28. Also shown in the figure is a power board 34, in communication with the mainboard 22, for taking AC electrical power delivered at the power cable socket 18 and converting it and regulating it as necessary to provide power for the various other components of the display device 10. The figure also shows a docking board 36 which provides electrical connections for the plug-in module 28. Typically, the plug-in module 28 can send video and audio signals to the mainboard 22 via the docking board 36, using one or more formats or protocols. The plug-in module 28 and the docking board 36 can also exchange control signals, using for example UART (universal asynchronous receiver-transmitter) communications, and electrical power. Likewise, the docking board 36 and the mainboard 22 can also exchange control signals, using for example UART (universal asynchronous receiver-transmitter) communications. The docking board 36 receives power via the power board 34.

[0037] A problem with such modules 28 having a high processing power is that the modules 28 generate a lot of heat in use. In particular, the processor(s) 30 typically consume high power, such as between around 15 watts to 35 watts or more, and so generate a lot of heat during use, especially in comparison with the processor(s) 24 typically provided by default on the mainboard 22 by the manufacturer of the display device 10 which may only consume around 5 watts or so. Moreover, in general, the greater the processing demands on the processor(s) 30 of such modules 28, the greater is the generation of heat. Excessive heat in the display device 10 can cause damage to one or more components of the display device 10.

[0038] Components of the display device 10 that are particularly susceptible to damage caused by heat include LEDs if used as the light sources in the display device 10 (whether in the display screen 14 itself to generate the pixels of the image directly or in a backlight to illuminate controllable elements, such as LCDs, in the display screen 14). As is known, the operating temperature, specifically the junction temperature, of an LED is the main factor for determining of the

lifetime of the LED: the higher the operating or junction temperature, the shorter the lifetime. The junction temperature of an LED is the temperature of the light-emitting portion of the LED. Moreover, the operating or junction temperature of an LED affects the amount or intensity of light that is output by the LED: the higher the operating or junction temperature, the lower the intensity of light that is output by the LED (for a particular drive current to the LED).

[0039] One way of dealing with overheating of the light sources such as LEDs is to reduce the drive current to the LED. This lowers the intensity of light that is output by the LED. However, this may not be acceptable as it lowers the brightness of the image that is displayed by the display device 10, which reduces the perceived quality of the image and, in some circumstances, can make it difficult to view the image. Moreover, because the amount of light that is output by an LED decreases with increasing temperature (at constant drive current), the brightness of the image has already been lowered simply because the temperature of the LEDs has risen. In turn, perversely, this would imply that a larger drive current should be used at higher temperatures in order to maintain the same brightness, which makes the problem of overheating even worse and also reduces the effective lifetime of the LEDs even further because the LEDs are being overdriven.

[0040] To solve this problem in accordance with examples of the present disclosure, the temperature of one or more of the light sources of the display device is monitored and the clock rate of at least one processor (in this example, the at least one processor 30 of the module 28) is controlled in dependence on the temperature of the at least one light source. For this, one or more of the light sources or, in this example, the backlight 16 generally is provided or associated with one or more temperature sensors 38 which obtain a measure the temperature of the one or more of the light sources. In an example, the output of the or each temperature sensor 38 is passed to the mainboard processor 24. The mainboard processor 24 passes control signals to the at least one processor 30 of the module 28 to control the clock rate of the module processor 30 in accordance with the sensed temperature. These control signals may be sent from the mainboard processor 24 to the module processor 30 via the docking board 36, using for example UART (universal asynchronous receiver-transmitter) or other communications. In general, if the temperature of the one or more of the light sources is high, then the mainboard processor 24 instructs the module processor 30 to reduce its clock rate. On the other hand, if the temperature of the one or more of the light sources is low, then the mainboard processor 24 instructs the module processor 30 to increase its clock rate.

[0041] The effect of this is that if the temperature of the one or more of the light sources increases, the operating temperature of the module processor 30 is caused to reduce by reducing the clock rate of the module processor 30. This lowers the production of heat within the display device 10 as a whole. In turn, this allows the temperature of the one or more of the light sources to drop. This allows the one or more of the light sources to continue to be driven with the same drive current so that they can continue to output light at the same brightness. Indeed, if the temperature of the one or more of the light sources drops, this can even allow the drive current for the one or more of the light sources to be lowered whilst still maintaining the same intensity or brightness of light output by the one or more of the light sources.

[0042] In a specific example, the mainboard processor 24 may provide control signals to the module processor 30 that instruct the module processor 30 to operate with a specific clock rate (which depends on the temperature of the one or more light sources, as discussed).

[0043] However, in practice, the clock rate, including particularly the maximum (safe) clock rate of the module processor 30, will depend on the specific model of module processor 30 and even on the characteristics of the individual module processor 30 owing to manufacturing variances during manufacture of the module processor 30.

[0044] Accordingly, in another example, the mainboard processor 24 may provide control signals to the module processor 30 that instruct the module processor 30 to operate with a clock rate that is a function of the maximum clock rate of the module processor 30. The mainboard processor 24 may instruct the module processor 30 to operate at one of a number of clock rates or a clock rate at a particular level in dependence on the temperature of the one or more light sources being within one of a corresponding number of ranges. The mainboard processor 24 may determine the number of clock rates or levels and corresponding number of ranges of temperatures. In an example, the mainboard processor 24 notes that the operating temperature of the one or more light sources is at a specific level, i.e. within one of the specified ranges of temperatures for the one or more light sources, and sends that level number to the module processor 30. The module processor 30 then calculates the clock rate at which it should be operating based on the level number and adjusts its clock rate accordingly.

[0045] To illustrate this further numerically, assume that the operating temperature of the one or more light sources is divided into three ranges or levels. For example, a temperature above 110°C, or a temperature in the range 110°C to 125°C, may be regarded as Level 1. (Temperatures above 125°C may cause the processor to shut down or reduce its clock rate to prevent damage in accordance with the processor's own thermal throttling.) A temperature in the range 90°C to 110°C may be regarded as Level 2. A temperature below 90°C may be regarded as Level 3. The mainboard processor 24 sends the Level number to the module processor 30 according to the temperature of the one or more light sources.

[0046] In this illustrative example, at the module processor 30 side, assume that the maximum clock rate for the module processor 30 is F_{max} and the minimum clock rate for the module processor 30 is F_{min} . (Such maximum and minimum

clock rates are typically determined and specified by the manufacturer of the module 28.) For a number N of levels of clock rate of the module processor 30, the actual clock rate F that should be set by the module processor 30 for itself in this example is given by:

$$F = F_{\min} + ((F_{\max} - F_{\min}) * (\text{level number} - 1) / (N - 1))$$

If $N = 1 \rightarrow F = F_{\min}$

[0047] Assume for this numerical example that $F_{\min} = 1$ GHz and $F_{\max} = 2$ GHz. $N = 3$ in this example, as discussed.

[0048] Therefore, in this illustrative example:

(i) if the temperature of the one or more light sources is between 110°C and 125°C, the mainboard processor 24 informs the module processor 30 that there are three levels and the light source temperature is at Level 1. The module processor 30 therefore sets its clock rate to be at 1 GHz.

(ii) if the temperature of the one or more light sources is between 90°C and 110°C, the mainboard processor 24 informs the module processor 30 there are three levels and the light source temperature is at Level 2. The module processor 30 therefore sets its clock rate to be at 1.5 GHz.

(iii) if the temperature of the one or more light sources is between 0°C and 90°C, the mainboard processor 24 informs the module processor 30 there are three levels and the light source temperature is at Level 3. The module processor 30 therefore sets its clock rate to be at 2 GHz.

[0049] This means that the mainboard processor 24 does not need to know the maximum clock rate (or the minimum clock rate) for the module processor 30, but can still instruct the module processor 30 to operate at a clock rate that is appropriate for that module processor 30 and the current temperature of the one or more light sources of the display device 10.

[0050] A number of options for measuring or obtaining a measure of the temperature of the light sources are possible.

[0051] As a first example, it is noted that the light sources, such as for example LEDs, in display devices are often mounted on or associated with heatsinks which draw heat away from the light sources. This is especially the case when the light sources are provided as part of a backlight, though heat sinks may also be provided in display devices that do not have backlights. In any case, the temperature of the light sources may be measured or monitored by measuring the temperature of the associated heat sink(s). One or more thermistors may be connected to the heat sink(s) for this purpose, with the output being passed to the mainboard processor 24.

[0052] As a second example, it is noted that the light sources in display devices are mounted on a circuit board via two pins on each light source. The temperature of these pins may be monitored or measured to obtain a more direct measurement of the temperature of the corresponding light source. For example, this may provide a more direct measurement of the junction temperature of an LED. This may be applied in the case that the display device has a backlight or in the case that the display device has no backlight and the light sources generate the pixels of the image directly (such as in display devices that use for example OLEDs or micro LEDs).

[0053] In either of these first and second examples, it may be sufficient to measure the temperature of only some of the light sources and it is not necessary to measure the temperatures of all of the light source.

[0054] As a third example in the case that the display device has a backlight, the temperature within the backlight unit as a whole may be monitored. That may then be used to obtain a measure of the temperature of the light source(s). A thermocouple or some other technique may be used for measuring the temperature within the backlight unit as a whole.

[0055] It will be understood that the processor or processing system or circuitry referred to herein may in practice be provided by a single chip or integrated circuit or plural chips or integrated circuits, optionally provided as a chipset, an application-specific integrated circuit (ASIC), field-programmable gate array (FPGA), digital signal processor (DSP), graphics processing units (GPUs), etc. The chip or chips may comprise circuitry (as well as possibly firmware) for embodying at least one or more of a data processor or processors, a digital signal processor or processors, baseband circuitry and radio frequency circuitry, which are configurable so as to operate in accordance with the exemplary embodiments. In this regard, the exemplary embodiments may be implemented at least in part by computer software stored in (non-transitory) memory and executable by the processor, or by hardware, or by a combination of tangibly stored software and hardware (and tangibly stored firmware).

[0056] Reference is made herein to data storage for storing data. This may be provided by a single device or by plural devices. Suitable devices include for example a hard disk and non-volatile semiconductor memory (including for example a solid-state drive or SSD).

[0057] Although at least some aspects of the embodiments described herein with reference to the drawings comprise

computer processes performed in processing systems or processors, the invention also extends to computer programs, particularly computer programs on or in a carrier, adapted for putting the invention into practice. The program may be in the form of non-transitory source code, object code, a code intermediate source and object code such as in partially compiled form, or in any other non-transitory form suitable for use in the implementation of processes according to the invention. The carrier may be any entity or device capable of carrying the program. For example, the carrier may comprise a storage medium, such as a solid-state drive (SSD) or other semiconductor-based RAM; a ROM, for example a CD ROM or a semiconductor ROM; a magnetic recording medium, for example a floppy disk or hard disk; optical memory devices in general; etc.

[0058] The examples described herein are to be understood as illustrative examples of embodiments of the invention. Further embodiments and examples are envisaged. Any feature described in relation to any one example or embodiment may be used alone or in combination with other features. In addition, any feature described in relation to any one example or embodiment may also be used in combination with one or more features of any other of the examples or embodiments, or any combination of any other of the examples or embodiments. Furthermore, equivalents and modifications not described herein may also be employed within the scope of the invention, which is defined in the claims.

Claims

1. A display device, the display device comprising:

at least one light source for generating light to be viewed by a viewer;
a temperature sensor for obtaining a measure of the temperature of the at least one light source; and
at least one processor constructed and arranged to provide instructions to control operation of the at least one light source;

wherein the clock rate of the at least one processor is controlled in dependence on the temperature of the at least one light source such that the at least one processor is arranged to operate at a low clock rate when the temperature of the at least one light source is high and the at least one processor is arranged to operate at a high clock rate when the temperature of the at least one light source is low.

2. A display device according to claim 1, wherein the processor is mounted on a plug-in module which can be plugged into and removed from the display device.

3. A display device according to claim 2, comprising:

a mainboard having a mainboard processor constructed and arranged to receive instructions for controlling operation of the at least one light source from the processor of the plug-in module and to pass instructions accordingly to the at least one light source.

4. A display device according to claim 3, wherein the mainboard processor is configured to receive temperature measurements for the at least one light source from the temperature sensor and to control the clock rate of the processor of the plug-in module in dependence on the temperature of the at least one light source.

5. A display device according to any of claims 1 to 4, wherein the at least one processor is configured to control its clock rate to be at one of a plurality of values which corresponds to the temperature of the at least one light source being within a corresponding one of a plurality of ranges of predetermined temperatures.

6. A display device according to claim 5 when dependent on claim 4, wherein the mainboard processor is configured to provide to said at least one processor an indication of the number of ranges of predetermined temperatures and an indication of the range in which the current temperature of the at least one light source falls, such that said at least one processor can determine its clock rate based on the number of ranges of predetermined temperatures and the indication of the range in which the current temperature of the at least one light source falls.

7. A display device according to any of claims 1 to 6, comprising:

a display screen which comprises a plurality of display elements which are controllable to selectively pass light; and

a plurality of light sources, the light sources being arranged as a backlight for illuminating the display elements of the display screen, the temperature sensor being configured to obtain a measure of the temperature of the light sources by measuring the temperature of the backlight.

8. A method of operating a display device, the display device comprising at least one light source for generating light to be viewed by a viewer, a temperature sensor for obtaining a measure of the temperature of the at least one light source, and at least one processor which provides instructions to control operation of the at least one light source, the method comprising:

obtaining a measure of the temperature of the at least one light source; and
controlling the clock rate of the at least one processor in dependence on the temperature of the at least one light source such that the at least one processor is arranged to operate at a low clock rate when the temperature of the at least one light source is high and the at least one processor is arranged to operate at a high clock rate when the temperature of the at least one light source is low.

9. A method according to claim 8, wherein the processor is mounted on a plug-in module which can be plugged into and removed from the display device.

10. A method according to claim 9, wherein the display device comprises a mainboard having a mainboard processor which receives instructions for controlling operation of the at least one light source from the processor of the plug-in module and to pass instructions accordingly to the at least one light source.

11. A method according to claim 10, wherein the mainboard processor receives temperature measurements for the at least one light source from the temperature sensor and controls the clock rate of the processor of the plug-in module in dependence on the temperature of the at least one light source.

12. A method according to any of claims 8 to 11, wherein the at least one processor controls its clock rate to be at one of a plurality of values which corresponds to the temperature of the at least one light source being within a corresponding one of a plurality of ranges of predetermined temperatures.

13. A method according to claim 12 when dependent on claim 11, wherein the mainboard processor provides to said at least one processor an indication of the number of ranges of predetermined temperatures and an indication of the range in which the current temperature of the at least one light source falls, and the at least one processor determines its clock rate based on the number of ranges of predetermined temperatures and the indication of the range in which the current temperature of the at least one light source falls.

14. A method according to any of claims 8 to 13, wherein the display device comprises:

a display screen which comprises a plurality of display elements which are controllable to selectively pass light; and
a plurality of light sources, the light sources being arranged as a backlight for illuminating the display elements of the display screen;
wherein the temperature sensor obtains a measure of the temperature of the light sources by measuring the temperature of the backlight.

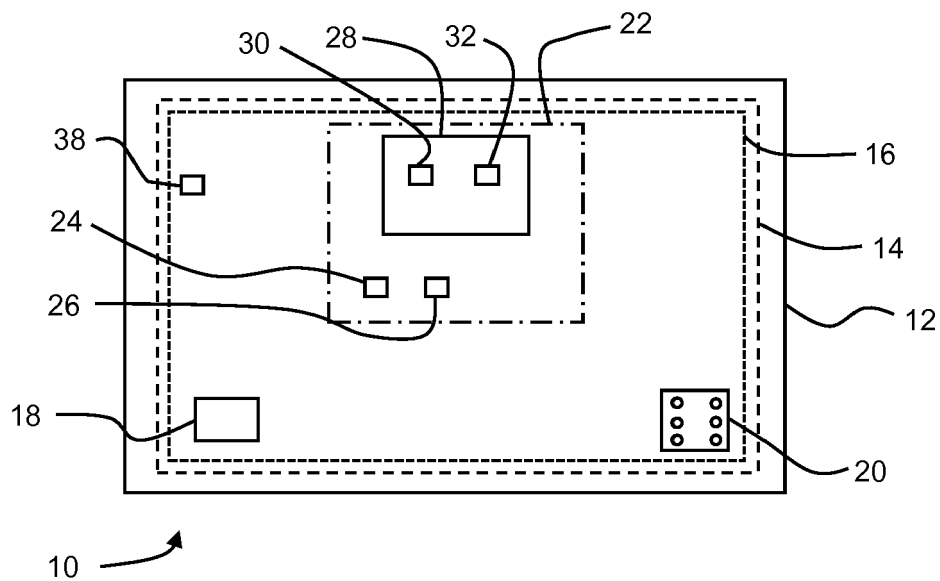


Fig. 1

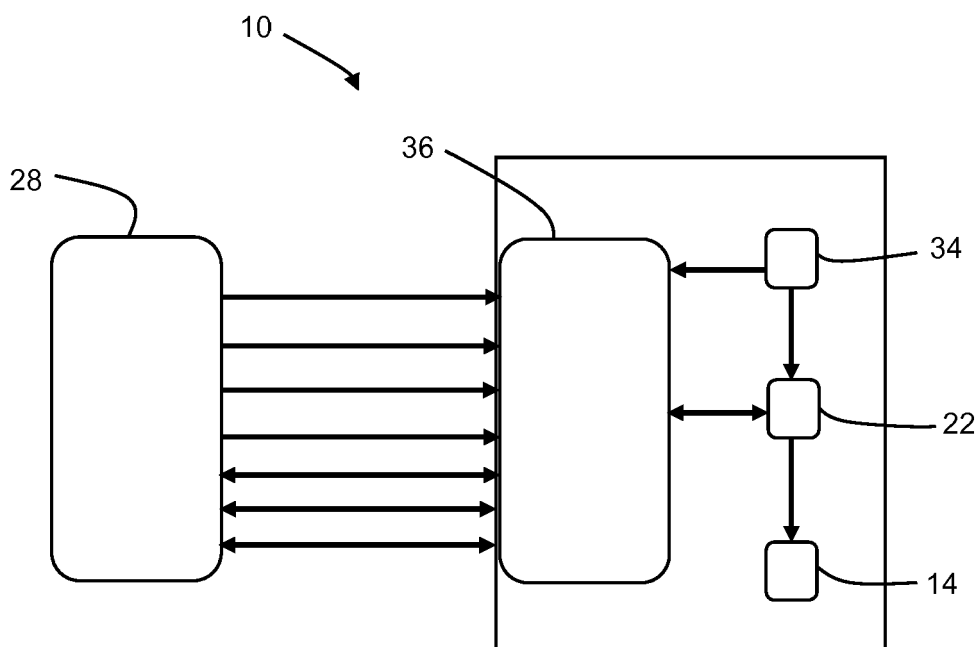


Fig. 2



EUROPEAN SEARCH REPORT

 Application Number
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			G09G
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 1 July 2019	Examiner Vázquez del Real, S
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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