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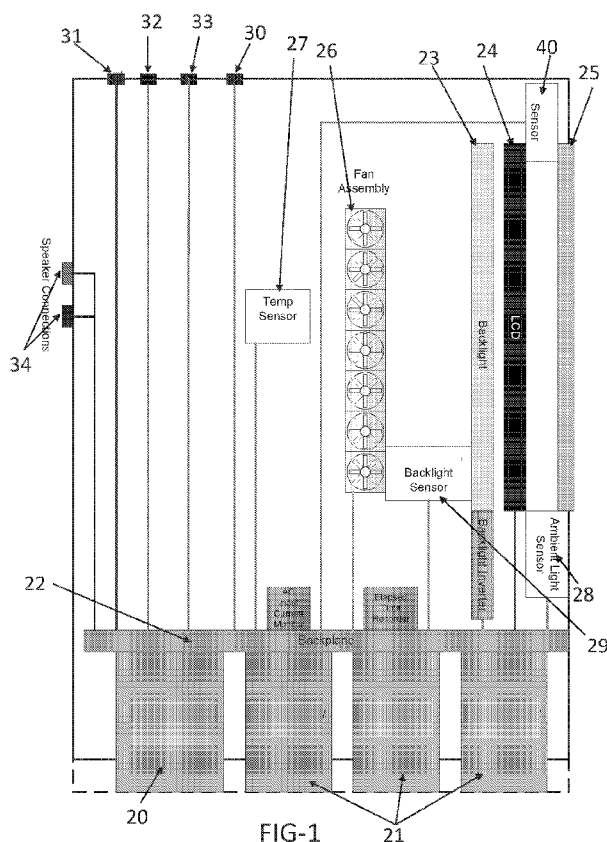
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- (54) Title: DISPLAY BRIGHTNESS CONTROL BASED ON LOCATION DATA



(57) Abstract: The exemplary embodiments herein provide a method and system for controlling the luminance of an electronic display, including determining the sunset and sunrise times for the day and determining whether the present time is between sunrise and sunset or between sunset and sunrise. The backlight may be driven at a daytime level if the present time is between sunrise and sunset, while the backlight may be driven at a nighttime level if the present time is between sunset and sunrise. In some embodiments, a microprocessor may process artificial ambient sensor (AAS) data to determine the desired backlight or display luminance. The AAS data may be adjusted for a sunset or sunrise transition time, as well as for an approximate percentage of cloud cover in the sky.



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Display Brightness Control Based on Location Data

Technical Field

[0002] Exemplary embodiments relate generally to a system and method for controlling the brightness of a display based on several types of data.

Background

[0003] Electronic displays have become useful for not only indoor entertainment purposes, but are now being utilized for indoor and outdoor advertising/informational purposes. For example, liquid crystal displays (LCDs), plasma displays, OLEDs, and many other flat panel displays are now being used to display information and advertising materials to consumers in locations outside of their own home or within airports, arenas, stadiums, restaurants/bars, gas station pumps, billboards, and even moving displays on the tops of automobiles or on the sides of trucks.

[0004] The rapid development of flat panel displays has allowed users to mount these displays in a variety of locations that were not previously available. Further, the popularity of high definition (HD) television has increased the demand for larger and brighter displays, especially large displays which are capable of producing HD video. The highly competitive field of consumer advertising has also increased the demand for large displays which are positioned outdoors, sometimes within direct sunlight or other high ambient light situations (street lights, building signs, vehicle headlights, and other

displays). In order to be effective, outdoor displays must compete with the ambient natural light to provide a clear and bright image to the viewer.

Summary of the Exemplary Embodiments

[0005] The exemplary embodiments herein provide a system and method for controlling the luminance of a display based on a combination of metrics. In some embodiments, the luminance is controlled based on the time of day, which is compared with sunrise/sunset data. In other embodiments, the system is controlled based on the time of day (when operating at nighttime) but controlled based on ambient light levels in the daytime. Other embodiments primarily operate based on the ambient light levels but switch to operation based on the time of day when a failure is detected in the ambient light sensor.

[0006] Some embodiments operate without the use of data from the ambient light sensor. In these embodiments, sunset and sunrise transition periods are calculated by the system and used to gradually ramp the display brightness up/down during these transition periods. Further embodiments also access local weather information and adjust the display brightness based on the percentage of cloud cover.

[0007] The exemplary embodiments herein disclosed are not intended to be exhaustive or to unnecessarily limit the scope of the embodiments. The exemplary embodiments were chosen and described in order to explain the principles so that others skilled in the art may practice the embodiments. Having shown and described exemplary embodiments, those skilled in the art will realize that many variations and modifications may be made to affect the described invention. Many of those variations and

modifications will provide the same result and fall within the spirit of the exemplary embodiments. It is the intention, therefore, to limit the embodiments only as indicated by the scope of the claims.

Brief Description of the Drawings

[0011] A better understanding will be obtained from a reading of the following detailed description and the accompanying drawings wherein identical reference characters refer to identical parts and in which:

[0012] **FIGURE 1** provides a block diagram for various electronic components which may be used within an exemplary electronic display assembly.

[0013] **FIGURE 2** provides a logical flow chart for performing a first embodiment of the method which is controlled only based on the display location data.

[0014] **FIGURE 3** provides a logical flow chart for performing a second embodiment of the method which is controlled initially by data from the ambient light sensor but switches to display location data if a failure is observed in the ambient light sensor.

[0015] **FIGURE 4** provides a logical flow chart for performing a third embodiment of the method which is controlled based on the display location data in the nighttime but switches to control based on the ambient light sensor in the daytime.

[0016] **FIGURE 5** provides a logical flow chart for performing a fourth embodiment of the method which is controlled based on the display location data in the nighttime but switches to control based on the ambient light sensor in the daytime unless a failure is detected in the ambient light sensor, at which point the system is controlled only by the display location data.

[0017] FIGURE 6 provides a graphical representation of a desired display brightness in response to raw ambient light sensor data.

[0018] FIGURE 7 provides a graphical representation of a desired display brightness in response to raw ambient light sensor data for this type of curve where the low ambient environments require a display set to a higher luminance level.

[0019] FIGURE 8 provides a logical flowchart for performing an embodiment that uses the AAS technique during sunset/sunrise transition times while using a nighttime/daytime level for the remaining times.

[0020] FIGURE 9 provides a logical flowchart for performing an embodiment that uses the AAS technique with only a single transition period while using a nighttime/daytime level for the remaining times.

[0021] FIGURE 10 provides a logical flowchart for performing the advanced embodiment that uses the AAS technique during sunset/sunrise transition times as well as the daytime while factoring in the local weather information.

Detailed Description of Preferred Embodiments

[0016] The invention is described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the exemplary embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. In the drawings, the size and relative sizes of layers and regions may be exaggerated for clarity.

[0017] It will be understood that when an element or layer is referred to as being "on" another element or layer, the element or layer can be directly on another element or layer or intervening elements or layers. In contrast, when an element is referred to as being "directly on" another element or layer, there are no intervening elements or layers present. Like numbers refer to like elements throughout. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

[0018] It will be understood that, although the terms first, second, third, etc., may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms are only used to distinguish one element, component, region, layer or section from another region, layer or section. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the present invention.

[0019] Spatially relative terms, such as "lower", "upper" and the like, may be used herein for ease of description to describe the relationship of one element or feature to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or operation, in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as "lower" relative to other elements or features would then be oriented "upper" relative the other elements or features. Thus, the exemplary term "lower" can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

[0020] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0021] Embodiments of the invention are described herein with reference to cross-section illustrations that are schematic illustrations of idealized embodiments (and intermediate structures) of the invention. As such, variations from the shapes of the illustrations as a result, for example, of manufacturing techniques and/or tolerances, are to be expected. Thus, embodiments of the invention should not be construed as limited to the particular shapes of regions illustrated herein but are to include deviations in shapes that result, for example, from manufacturing.

[0022] For example, an implanted region illustrated as a rectangle will, typically, have rounded or curved features and/or a gradient of implant concentration at its edges rather than a binary change from implanted to non-implanted region. Likewise, a buried region formed by implantation may result in some implantation in the region between the buried region and the surface through which the implantation takes place. Thus, the regions illustrated in the figures are schematic in nature and their shapes are not intended to illustrate the actual shape of a region of a device and are not intended to limit the scope of the invention.

[0023] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0024] **FIGURE 1** provides a block diagram for various electronic components which may be used within an exemplary electronic display assembly. One or more power modules 21 may be placed in electrical connection with a backplane 29, which could be provided as a printed circuit board which may facilitate electrical communication and/or power between a number of components in the display assembly. A display controlling assembly 20 may also be in electrical connection with the backplane 22. The display controlling assembly 20 preferably includes a number of different components, including but not limited to a video player, electronic storage, and a microprocessor which is programmed to perform any of the logic that is described within this application.

[0025] This figure also shows a backlight 23, LCD assembly 24, and a front transparent display panel 25. The backlight 23 may be a CCFL or light emitting diode (LED) backlight. It should be noted that although the setup for an LCD is shown, embodiments can be practiced with any electronic image-producing assembly. Thus any other flat panel display could be used such as plasma, light-emitting polymers, and organic light emitting diode (OLED) displays. When the display type does not include a traditional backlight, then the term “drive backlight” as used herein, can be replaced with “drive display” and the term “backlight level” as used herein, can be replaced with “display level.” A fan

assembly 26 is shown for optionally cooling displays which may reach elevated temperatures. One or more temperature sensors 27 may be used to monitor the temperature of the display assembly, and selectively engage fan assembly 26 when cooling is needed. An ambient light sensor 28 may be positioned to measure the amount of ambient light that is contacting the front display panel 25, although this is not required. As described below, some embodiments may use the ambient light sensor 28 in a limited capacity, but a preferred embodiment would operate without the need for the ambient light sensor 28 at all.

[0026] A variety of different electrical inputs/outputs are also shown, and all or only a select few of the inputs/outputs may be practiced with any given embodiment. The AC power input 30 delivers the incoming power to the backplane 22. A video signal input 31 can receive video signals from a plurality of different sources. In a preferred embodiment the video signal input 31 would be an HDMI input. Two data interface connections 32 and 33 are also shown. The first data interface connection 32 may be an RS2332 port or an IEEE 802.3 jack which can facilitate user setup and system monitoring. Either form of the connection should allow electrical communication with a personal computer. The second data interface connection 33 may be a network connection such as an Ethernet port, wireless network connection, or a satellite network connection. The second data interface connection 33 preferably allows the display assembly to communicate with the internet, and may also permit a remote user to communicate with the display assembly. The second data interface connection 33 can also provide the video data through a network source. The second data interface connection 33 can also be utilized to transmit display settings, error messages, and various other forms of data to a website for access

and control by the user. Optional audio connections 34 may also be provided for connection to internal or external speaker assemblies. It is not required that the data inputs 31, 32, and 33 received their data through a wired connection, as many embodiments may utilize wireless networks or satellite networks to transmit data to the display assembly. The various types of wireless/satellite receivers and transmitters have not been specifically shown due to the large number of variable types and arrangements, but these are understood by a person of ordinary skill in the art.

[0027] A backlight sensor 29 is preferably placed within the backlight cavity to measure the amount of luminance being generated within the backlight cavity. Additionally, a display luminance sensor 40 is preferably positioned in front of the display 24 in order to measure the amount of luminance exiting the display 24. Either sensor can be used in a traditional feed-back loop to evaluate the control signals being sent to the power modules 21 and what resulting backlight luminance or display luminance is generated by the display in response. As shown below, ambient light data (either actual measurements or artificial ambient light sensor data, herein “AAS”) may be used to select either the desired display luminance or backlight luminance. Either technique can be used with the various embodiments herein.

[0028] Information for monitoring the status of the various display components may be transmitted through either of the two data interface connections 32 and 33, so that the user can be notified when a component may be functioning improperly, about to fail, or has already failed and requires replacement. The information for monitoring the status of the display may include, but is not limited to: power supply status, power supply test results, AC input current, temperature sensors, fan speed, video input status, firmware

revision, and light level sensors. Also, the user may adjust settings including, but not limited to: on/off, brightness level, enabling ambient light sensor, various alert settings, IP address, customer defined text/video, display matrix settings, display of image settings via OSD, and various software functions. In some embodiments, these settings can be monitored and altered from either of the two data interface connections 32 and 33.

[0029] **FIGURE 2** provides a logical flow chart for performing a first embodiment of the method which is controlled only based on the display location data. As an initial step in this embodiment, the system preferably determines the geographical location data for the display. This can be performed in a number of ways. First, the physical address of the display may be used to determine the city/state in which the display is located. Second, the physical address of the display can be exchanged for the latitude and longitude coordinates. This technique can be performed by accessing a number of online tools, including but not limited to www.latlong.net. Third, the location of the display can be determined by reading coordinates from a GPS capable smart device which may form a part of the display controlling assembly 20. If the coordinates result in a physical address then this can be converted to the latitude and longitude coordinates, or vice versa by the techniques noted above.

[0030] Once the location of the display is determined, the sunset and sunrise times for this location are preferably determined. The timing for performing this step can vary. In some embodiments, this step could be performed only once, with 365 days of data being used for the display throughout the remainder of the display's lifetime. Alternatively, this step could be performed annually, monthly, weekly, or even daily. This step can also be performed in a number of ways. First, when given a physical address, the system can

determine the sunrise/sunset times based on this address and store them within the electronic storage on the display controlling assembly 20. Second, when given latitude/longitude coordinates, the system can determine the sunrise/sunset times based on these coordinates and store them within the electronic storage on the display controlling assembly 20. The location data can be converted to sunrise/sunset times by accessing any number of online databases, including but not limited to: www.sunrisesunset.com, www.suncalc.net, and various NOAA online tools. Additionally, the latitude and longitude data can be used to calculate sunrise/sunset times based on the sunrise equation:

[0031] $\cos \omega_o = -\tan \phi \times \tan \delta$ where:

[0032] ω_o is the hour angle at either sunrise (when negative value is taken) or sunset (when positive value is taken);

[0033] ϕ is the latitude of the observer on the Earth; and

[0034] δ is the sun declination.

[0035] It should be noted that the steps of determining geographical location data for the display and determining approximate sunrise/sunset times based on the geographical location data, may be performed before the display is shipped to its actual location. In other embodiments, the display may be installed within its actual location prior to performing these steps.

[0036] Once the approximate sunrise/sunset times are determined (and preferably stored at the display), the system would then check to see what the current time is and determine whether it is currently night or day. While the figure reads the logic as “does the current time fall after sunset and before sunrise,” it seems clear that this could also

be performed by determining “does the current time fall after sunrise and before sunset” and it makes no difference in any of the subject embodiments. In this first embodiment, if the system determines that it is currently nighttime, the backlight is driven at the nighttime level. Alternatively, if the system determines that it is daytime, the backlight is driven at the daytime level.

[0037] The relative daytime level and nighttime level for the backlight can be selected for this embodiment through a simple binary operation where a first luminance value for the backlight is desired during nighttime and a second luminance value for the backlight is desired during daytime. The system may push as much power as necessary to the backlight 23 in order to read the desired luminance value from the backlight sensor 29. The power levels can be adjusted through the feedback coming from the backlight sensor 29 to ensure that the desired luminance level of the backlight 23 is maintained. Alternatively, the desired luminance can be measured based on the level of luminance for the light which is exiting the display 24, measured by the light sensor 40. The sensor 40 can also provide the feedback to the system to ensure that the proper amount of power is being sent to the backlight 23 to ensure adequate luminance levels exiting the display.

[0038] The dashed lines on the figure indicate the option of the system returning to determine the approximate sunrise/sunset times, if practicing an embodiment where this data is updated annually, monthly, weekly, or daily.

[0039] **FIGURE 3** provides a logical flow chart for performing a second embodiment of the method which is controlled initially by data from the ambient light sensor 28 but switches to display location data if a failure is observed in the ambient light sensor 28. In this embodiment, the system regularly checks to determine if the ambient light sensor 28

is working properly. This can be checked in a number of ways, including a quick reference to the time of day and the ambient light sensor readings. Thus, if it is 3:00 a.m. in Lincoln, Nebraska, we should see very low light levels and a very high light level reading would indicate some error or failure in the ambient light sensor 28. Alternatively, if it is 3:00 p.m. in Lincoln, Nebraska and there is a very low light reading, this could also indicate some error or failure in the ambient light sensor 28. Other signal analysis steps could also be performed where no signal whatsoever would indicate an error or failure or a very high voltage reading could also indicate an error or failure. Failures in the ambient light sensor 28 can also be determined by signal analysis methods which look at the amount of noise and randomness in the sensor data. A measured amount of noise or randomness that is above some threshold level can also be used to indicate a failure in the sensor.

[0040] If the ambient light sensor 28 is working properly, it is preferably used to determine the amount of luminance contacting the front display panel 25. Based on this information, the system may determine the desired backlight level based on this data. This step can also be performed in a number of ways. First, a lookup table may be used where a particular reading from the ambient light sensor 28 will correspond with a desired luminance reading from the light sensor 29 in the backlight cavity or light sensor 40 in front of the display 24. Second, an equation or ratio can be used where the desired luminance from the light sensor 29 or light sensor 40 may be calculated based on the data from the ambient light sensor 28. Third, the more simplistic daytime/nighttime settings can be used when the sensor 28 indicates daytime/nighttime and when the sensor 28 indicates a transition period (i.e. dawn/dusk) the display may default to the daytime setting.

[0041] If at any point during this operation the system determines that the ambient light sensor 28 is not working properly, the system preferably shifts to the display location data method described above.

[0042] **FIGURE 4** provides a logical flow chart for performing a third embodiment of the method which is controlled based on the display location data in the nighttime but switches to control based on the ambient light sensor 28 in the daytime. This is a type of hybrid approach where the backlight is driven at a desired (preferably constant) nighttime level anytime the display is between sunset and sunrise while adjusting to the various levels of ambient light when operating during the daytime or other transition periods (i.e. dawn/dusk).

[0043] **FIGURE 5** provides a logical flow chart for performing a fourth embodiment of the method which is controlled based on the display location data in the nighttime but switches to control based on the ambient light sensor 28 in the daytime unless a failure is detected in the ambient light sensor 28, at which point the system is controlled only by the display location data. This embodiment is similar to the embodiment shown and described for Figure 4 above, with the additional check to see if the ambient light sensor 28 is functioning properly. If not, then the backlight may be driven to a desired daytime level (preferably constant) based on the time of day, and will not consider the readings of the ambient light sensor.

[0044] It should be noted that when driving the backlight based on the location data and/or time of day, the system does not have to choose one luminance for daytime and one luminance for nighttime (although some embodiments use this method). The system can also use the time of day to slightly adjust the amount of luminance from the backlight.

Thus, while 7:15 a.m. and 1:30 p.m. are each occurring after sunrise and before sunset, the system does not have to drive the backlight at the same luminance for each time. Thus, as used herein, the terms “nighttime level” and “daytime level” can represent luminance values that are also obtained through a lookup table (based on time of day) or an equation/calculation (based on time of day). In this manner, the system could drive the daytime level at 1:30 p.m. higher than the daytime level at 7:15 a.m. given the assumption that there will be more ambient light present during the afternoon than in the early morning (or late evening for that matter).

[0045] **FIGURE 6** provides a graphical representation of a desired display brightness in response to raw ambient light sensor data. This is an example, and not required for any specific embodiment. It has been found, that the human eye is more sensitive to luminance variations in low ambient light environments as compared to high ambient light environments. Therefore, some embodiments of the invention may use a more aggressive response curve at the lower ambient light environments. **FIGURE 7** provides a graphical representation of a desired display brightness in response to raw ambient light sensor data for this type of curve where the low ambient environments require a display set to a higher luminance level. Either curve (Fig. 6 or Fig. 7), or another curve, could be used to create the look-up table or perform an equation to determine the desired display brightness for each ambient environment.

[0046] It should be noted that while Figures 6 and 7 are shown in terms of display brightness, the exemplary embodiments herein can be based on either display brightness or backlight brightness, depending on which type(s) of electronic display is being used and the sensors used to measure the luminance output (if used). It should also be noted

that the values for Figures 6 and 7 are based on actual raw data from ambient light sensors, but actual data is not necessarily used when using some of the exemplary embodiments herein. Thus, the calculation of artificial ambient sensor (AAS) values is described below, and these AAS values can be used with the relationships shown in Figures 6 and 7 to determine the desired display brightness. In other words, using the relationship shown in Figures 6 and 7 does not require the use of actual ambient light sensor data, as it can be used when working with AAS data as well. While based on the performance of real ambient sensors with real data, it is not required that actual raw data from ambient light sensors is used for any of the embodiments herein.

[0047] It should also be noted that changes from “nighttime level” backlight luminance to “daytime level” backlight luminance should preferably not happen in a drastic manner, where an abrupt change or flicker in the display could be observed by a viewer. It is preferable that the changes in backlight luminance occur in a ramp-wise fashion, where the backlight does not suddenly shift to a new luminance, but instead gradually changes to a new luminance over a (shorter or longer) period of time that would make it less noticeable to a viewer.

[0048] It has been discovered, that anomalies in the display environment can sometimes create variations in the ambient light sensor data that can cause the display to change brightness levels drastically, even though the surrounding environment has not changed quite as drastically. For example, the ambient light sensor may be positioned within a shadow while the rest of the display is not. This select-shadowing can be caused by a number of obstructions, including but not limited to light posts, trees, passing vehicles, and/or construction equipment. Other anomalies can create variability in the

ambient light sensor data, including variations in: the response of each different sensor, the response of the sensor over temperature changes, variations in the positioning of the light sensor in each display, and variations in the typical ambient environment of the display over time.

[0049] In some embodiments, as mentioned above, the system can function without the use of data from the ambient light sensor. This however does typically limit some of the functionality of the system and its benefits, specifically power saving benefits, and can sometimes produce drastic changes in the display luminance. However, the following embodiments provide a system and method for controlling the luminance of an electronic display by producing artificial ambient light sensor data (AAS).

[0050] In one embodiment, generating artificial ambient sensor data involves defining the following parameters:

[0051] (1) Desired Nighttime Level – the desired display brightness at nighttime.

[0052] (2) Desired Daytime Level – the desired display brightness during the daytime.

[0053] (3) High Ambient Reading (HA) – the approximate raw data received by the ambient light sensor when experiencing the highest ambient light levels for the display environment.

[0054] (4) GPS coordinates for the display location or the address/City/State.

[0055] (5) Sunrise transition period (t^{sr}) – the amount of time (usually measured in seconds) to transition from a nighttime ambient light sensor reading to a daytime ambient light sensor reading.

[0056] (6) Sunset transition period (t^{ss}) – the amount of time (usually measured in seconds) to transition from a daytime ambient light sensor reading to a nighttime ambient light sensor reading.

[0057] For this embodiment, during the sunrise transition period, the artificial ambient sensor (AAS) data can be calculated in the following manner, where t^i provides the time in transition (i.e. t^i varies between zero and t^{sr}).

[0058] $AAS \text{ for sunrise} = (t^i * HA) / t^{sr}$.

[0059] Similarly, the AAS for sunset can be calculated in the following manner, where t^i provides the time in transition (i.e. t^i varies between zero and t^{ss}).

[0060] $AAS \text{ for sunset} = HA - (t^i * HA) / t^{ss}$.

[0061] Once AAS for either transition period has been calculated, the desired backlight level can be determined from any of the ambient light vs. display brightness relationships described above.

[0062] **FIGURE 8** provides a logical flowchart for performing an embodiment that uses the AAS technique during sunset/sunrise transition times while using a nighttime/daytime level for the remaining times.

[0063] In some embodiments, the sunset transition period and the sunrise transition period may be similar or substantially the same. In this case, it may not be necessary to have two transition periods. Instead, one transition period may be used. **FIGURE 9** provides a logical flowchart for performing an embodiment that uses the AAS technique with only a single transition period while using a nighttime/daytime level for the remaining times.

[0064] In an advanced embodiment, the system and method can also utilize local weather information to further tailor the display brightness, without requiring actual data from the ambient light sensor. The local weather information can be obtained from available web APIs or other online weather information which may be accessed at a predetermined time interval (ex. every 15 minutes). Here, a weather factor (WF) is used where:

[0065] If it is daytime or any transition period: $WF = 4 * C^i$, where C^i = Clearness percentage with a higher percentage representing a clear sky and a lower percentage representing a large amount of cloud cover. Of course the inversion could be used, where a higher percentage represents more cloud cover and a lower percentage represents less cloud cover. Either technique can be used by a person of ordinary skill in the art.

[0066] For this embodiment, during the sunrise transition period, the artificial ambient sensor (AAS) data can be calculated in the following manner.

[0067] $AAS \text{ for sunrise} = (t^i * (HA * WF)) / t^{sr}$.

[0068] Similarly, the AAS for sunset can be calculated in the following manner.

[0069] $AAS \text{ for sunset} = (HA * WF) - (t^i * (HA * WF)) / t^{ss}$.

[0070] If it is daytime, $AAS = HA * WF$.

[0071] If it is nighttime, $AAS = 0$.

[0072] Once AAS for either transition period or the daytime has been calculated, the desired backlight level can be determined from any of the ambient light vs. display brightness relationships described above.

[0073] **FIGURE 10** provides a logical flowchart for performing the advanced embodiment that uses the AAS technique during sunset/sunrise transition times as well as the daytime while factoring in the local weather information.

[0074] For example, when during the daytime (i.e. not within either transition period or nighttime) and where it is overcast and raining, the relevant calculations would be:

[0075] $C_i = 10\%$ clearness percentage

[0076] $HA = 500$

[0077] Weather factor = $4 * 0.10 = 0.40$

[0078] $AAS = 500 * 0.40 = 300$

[0079] Referencing Figure 6 with ambient sensor input of 300, Desired Display Luminance ≈ 1040 nits.

[0080] Referencing Figure 7 with ambient sensor input of 300, Desired Display Luminance ≈ 1965 nits.

[0081] Note that without correction for local weather conditions, the daytime value would likely be 500, which would mean the Desired Display Luminance = 2500 nits. From here we see significant power savings due to the overcast skies.

[0082] For the same example, if the display is halfway through a sunrise or sunset transition, the calculated light sensor value and corresponding desired brightness would be:

[0083] $t^{sr} = 1800$ seconds

[0084] $t^i = 900$ seconds

[0085] $HA = 500$

[0086] Weather factor = $4 * 0.10 = 0.40$

[0087] $AAS = (900 * 500 * 0.40) / 1800 = 100$

[0088] Referencing Figure 6 with ambient light sensor input of 100, Desired Display Luminance $\sim = 465$ nits*

[0089] Referencing Figure 7 with ambient sensor input of 100 Desired Display Luminance $\sim = 1030$ nits.

[0090] Without correction for local conditions, the AAS value would be 250 which corresponds with a Desired Display Luminance $\sim = 850$ nits.

[0091] Having shown and described preferred embodiments, those skilled in the art will realize that many variations and modifications may be made to affect the described embodiments and still be within the scope of the claims. Thus, many of the elements indicated above may be altered or replaced by different elements which will provide the same result and fall within the spirit of the claimed embodiments. It is the intention, therefore, to limit the invention only as indicated by the scope of the claims.

CLAIMS

What is claimed is:

1. An electronic display assembly comprising:

a liquid crystal display;

a backlight placed behind the liquid crystal display;

one or more power modules in electrical connection with the backlight; and

a microprocessor in electrical connection with the power module(s) and adapted to:

direct the power module(s) to drive the backlight at a daytime level if the present time is between sunrise and sunset, and

direct the power module(s) to drive the backlight at a nighttime level if the present time is between sunset and sunrise.

2. The electronic display assembly of claim 1 further comprising:

an ambient light sensor placed in electrical connection with the microprocessor.

3. The electronic display assembly of claim 2 wherein:

the microprocessor is further adapted to direct the power module(s) to drive the backlight based on data from the ambient light sensor.

4. The electronic display assembly of claim 3 wherein:

the microprocessor is further adapted to determine a possible failure in the ambient light sensor.

5. The electronic display assembly of claim 2 wherein:

the microprocessor is further adapted to determine a possible failure in the ambient light sensor and directing the power module(s) to drive the backlight at a nighttime or daytime level when a failure in the ambient light sensor is detected, and directing the power module(s) to drive the backlight based on data from the ambient light sensor when no failure is detected.

6. The electronic display assembly of claim 1 wherein:

the microprocessor is further adapted to determine whether the present time is during a sunset or sunrise transition period and
calculate artificial ambient sensor data (AAS) for sunset, if during a sunset transition period,
calculate artificial ambient sensor data (AAS) for sunrise, if during a sunrise transition period, and
direct the power module(s) to drive the backlight based on the AAS data.

7. The electronic display assembly of claim 1 wherein:

the microprocessor is further adapted to determine whether the present time is during a sunset or sunrise transition period and
calculate artificial ambient sensor data (AAS) if during a sunset or sunrise transition period, and
direct the power module(s) to drive the backlight based on the AAS data.

8. The electronic display assembly of claim 1 wherein:

the microprocessor is further adapted to determine local weather information and calculate artificial ambient sensor data (AAS) based on the local weather information, and direct the power module(s) to drive the backlight based on the AAS data.

9. An electronic display assembly comprising:

a liquid crystal display;

a backlight placed behind the liquid crystal display;

one or more power modules in electrical connection with the backlight; and

a microprocessor in electrical connection with the power module(s) and adapted to:

determine the sunset and sunrise times for a day, including the sunset transition period and the sunrise transition period,

determine if the present time is during a sunrise transition, daytime, a sunset transition, or nighttime,

calculate artificial ambient sensor data (AAS) for sunrise and direct the power module(s) to drive the backlight based on the AAS data if the present time is during a sunrise transition period,

direct the power module(s) to drive the backlight at a daytime level if the present time is daytime,

calculate artificial ambient sensor data (AAS) for sunset and direct the power module(s) to drive the backlight based on the AAS data if the present time is during a sunset transition period, and

direct the power module(s) to drive the backlight at a nighttime level if the present time is nighttime.

10. The electronic display assembly of claim 9 wherein:

the microprocessor directs the power module(s) to drive the backlight based on the AAS data by calculating a desired display luminance based on ambient light sensor readings.

11. The electronic display assembly of claim 9 wherein:

the microprocessor directs the power module(s) to drive the backlight based on the AAS data by using a table of desired display luminance values based on ambient light sensor readings.

12. The electronic display assembly of claim 9 wherein:

the microprocessor directs the power module(s) to drive the backlight based on the AAS data by calculating a desired backlight luminance based on ambient light sensor readings.

13. The electronic display assembly of claim 9 wherein:

the microprocessor directs the power module(s) to drive the backlight based on the AAS data by using a table of desired backlight luminance values based on ambient light sensor readings.

14. The electronic display assembly of claim 9 wherein:

the microprocessor is further adapted to determine local weather information and wherein the AAS data is calculated based on the local weather information.

15. The electronic display assembly of claim 14 wherein:

the local weather information is determined by calculating a percentage of cloud cover.

16. An electronic display assembly comprising:

a liquid crystal display;

a backlight placed behind the liquid crystal display;

one or more power modules in electrical connection with the backlight;

a GPS device; and

a microprocessor in electrical connection with the power module(s) and the GPS device and adapted to:

determine the location data for the liquid crystal display through the GPS device,

direct the power module(s) to drive the backlight based on the data from the GPS device.

17. The electronic display assembly of claim 16 wherein:

the microprocessor does not use data from an ambient light sensor to drive the backlight.

18. The electronic display assembly of claim 16 wherein:

the microprocessor determines the sunrise and sunset times based on the location data from the GPS device.

19. The electronic display assembly of claim 18 wherein:

the microprocessor determines the sunrise and sunset times based on the longitude and latitude coordinates of the electronic display.

20. The electronic display assembly of claim 19 wherein:

the microprocessor determines the sunrise and sunset times by calculating the sunrise equation.

21. A method for controlling the luminance of an electronic display, comprising the steps of:

determining the sunset and sunrise times for the day;

determining whether the present time is between sunrise and sunset or between sunset and sunrise; and

driving the backlight based on whether the present time is between sunrise and sunset or between sunset and sunrise.

22. The method of claim 21 further comprising the steps of:

driving the backlight at a daytime level if the present time is between sunrise and sunset;

driving the backlight at a nighttime level if the present time is between sunset and sunrise;

gradually increasing the backlight level when transitioning from the nighttime level to the daytime level; and

gradually decreasing the backlight level when transitioning from the daytime level to the nighttime level.

23. The method of claim 21 wherein:

the step of driving the backlight is performed without any actual input from an ambient light sensor.

24. The method of claim 22 wherein:

the step of driving the backlight at a daytime level is performed by reading data from an ambient light sensor and selecting a desired backlight level based on the data from the ambient light sensor.

25. The method of claim 22 wherein:

the step of driving the backlight at a daytime level is performed by driving the backlight at a predetermined constant daytime level, without utilizing any input from an ambient light sensor.

26. The method of claim 22 wherein:

the step of driving the backlight at a daytime level is performed by calculating artificial ambient sensor data (AAS) for the present time and driving the backlight based on the AAS data.

27. The method of claim 21 further comprising the steps of:

determining whether the present time is during a sunset or sunrise transition period; and
calculating artificial ambient sensor data (AAS) if during a sunset or sunrise transition period, and
driving the backlight based on the AAS data if during a sunset or sunrise transition period.

28. The method of claim 21 further comprising the steps of:

determining local weather information and
calculating artificial ambient sensor data (AAS) based on the local weather information, and
driving the backlight based on the AAS data.

29. A method for controlling the luminance of an electronic display, comprising the steps of:

determining the sunset and sunrise times for the day, including the sunset transition period and the sunrise transition period,

determining if the present time is during a sunrise transition, daytime, a sunset transition, or nighttime,
calculating artificial ambient sensor data (AAS) for sunrise and driving the backlight based on the AAS data if the present time is during a sunrise transition period,
driving the backlight at a daytime level if the present time is daytime,
calculating AAS data for sunset and driving the backlight based on the AAS data if the present time is during a sunset transition period, and
driving the backlight at a nighttime level if the present time is nighttime.

30. The method of claim 29 wherein the step of driving the backlight based on AAS data is performed by:

determining a desired display luminance based on ambient light sensor readings;
and
driving the backlight to obtain the desired display luminance.

31. The method of claim 29 wherein the step of driving the backlight based on AAS data is performed by:

retrieving a desired display luminance from a table of desired display luminance values based on ambient light sensor readings, by matching the AAS data to an ambient light sensor reading and corresponding desired display luminance; and
driving the backlight to obtain the desired display luminance.

32. The method of claim 29 wherein the step of driving the backlight based on AAS data is performed by:

calculating a desired backlight luminance based on a mathematical relationship between ambient light sensor readings and backlight luminance where the AAS data is used as the ambient light sensor reading; and driving the backlight to the desired backlight luminance.

33. The method of claim 29 wherein the step of driving the backlight based on AAS data is performed by:

using a table of desired backlight luminance values based on ambient light sensor readings where the AAS data is used as the ambient light sensor readings to determine a desired backlight luminance value; and driving the backlight to the desired backlight luminance value.

34. The method of claim 29 further comprising the step of:

determining local weather information and wherein the step of calculating the AAS data is performed based on the determined local weather information.

35. The method of claim 34 wherein:

the step of determining the local weather information is performed by calculating a percentage of cloud cover.

36. A method for controlling the luminance of an electronic display, comprising the steps of:

determine the location data for the electronic display through a GPS device; and
driving the luminance of the electronic display based on the location data from the
GPS device.

37. The method of claim 36 wherein:

the step of driving the luminance of the display is performed without using any data
from an ambient light sensor.

38. The method of claim 36 wherein:

the step of driving the luminance of the display is performed by
calculating the sunrise and sunset times based on the location data from the
GPS device.

39. The method of claim 38 wherein:

the step of calculating the sunrise and sunset times is performed based on
the longitude and latitude coordinates of the electronic display.

40. The method of claim 39 wherein:

the step of calculating the sunrise and sunset times is performed by calculating
the sunrise equation.

41. An electronic display assembly comprising:

a liquid crystal display;

a backlight placed behind the liquid crystal display; and

a microprocessor in electrical connection with the backlight and adapted to drive the backlight based on sunrise and sunset times.

42. The electronic display assembly of claim 41 wherein:

the microprocessor does not use data from an ambient light sensor to drive the backlight.

43. The electronic display assembly of claim 41 wherein:

the microprocessor gradually increases power to the backlight during a sunrise transition period, and
gradually decreases power to the backlight during a sunset transition period.

44. The electronic display assembly of claim 41 wherein:

the microprocessor determines the sunrise and sunset times based on the geographical location of the electronic display.

45. The electronic display assembly of claim 41 wherein:

the microprocessor determines the sunrise and sunset times based on the longitude and latitude coordinates of the electronic display.

46. The electronic display assembly of claim 41 wherein:

the microprocessor determines the sunrise and sunset times based on the city where the electronic display is located.

47. The electronic display assembly of claim 41 wherein:

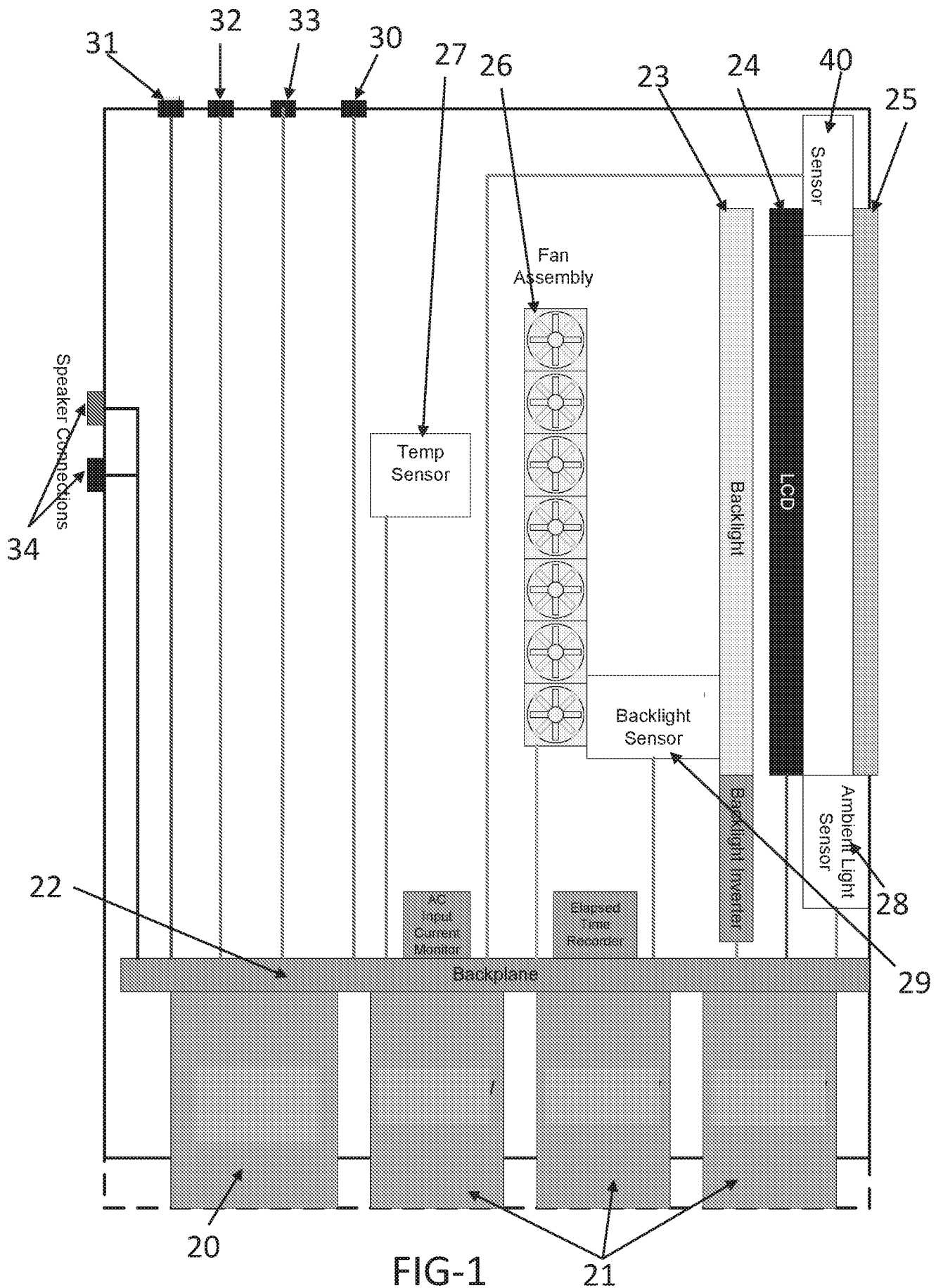
the microprocessor determines the sunrise and sunset times by calculating the sunrise equation.

48. An electronic display assembly comprising:

a liquid crystal display;

a backlight placed behind the liquid crystal display; and

a microprocessor in electrical connection with the backlight and adapted to drive the backlight based on data from a GPS device.



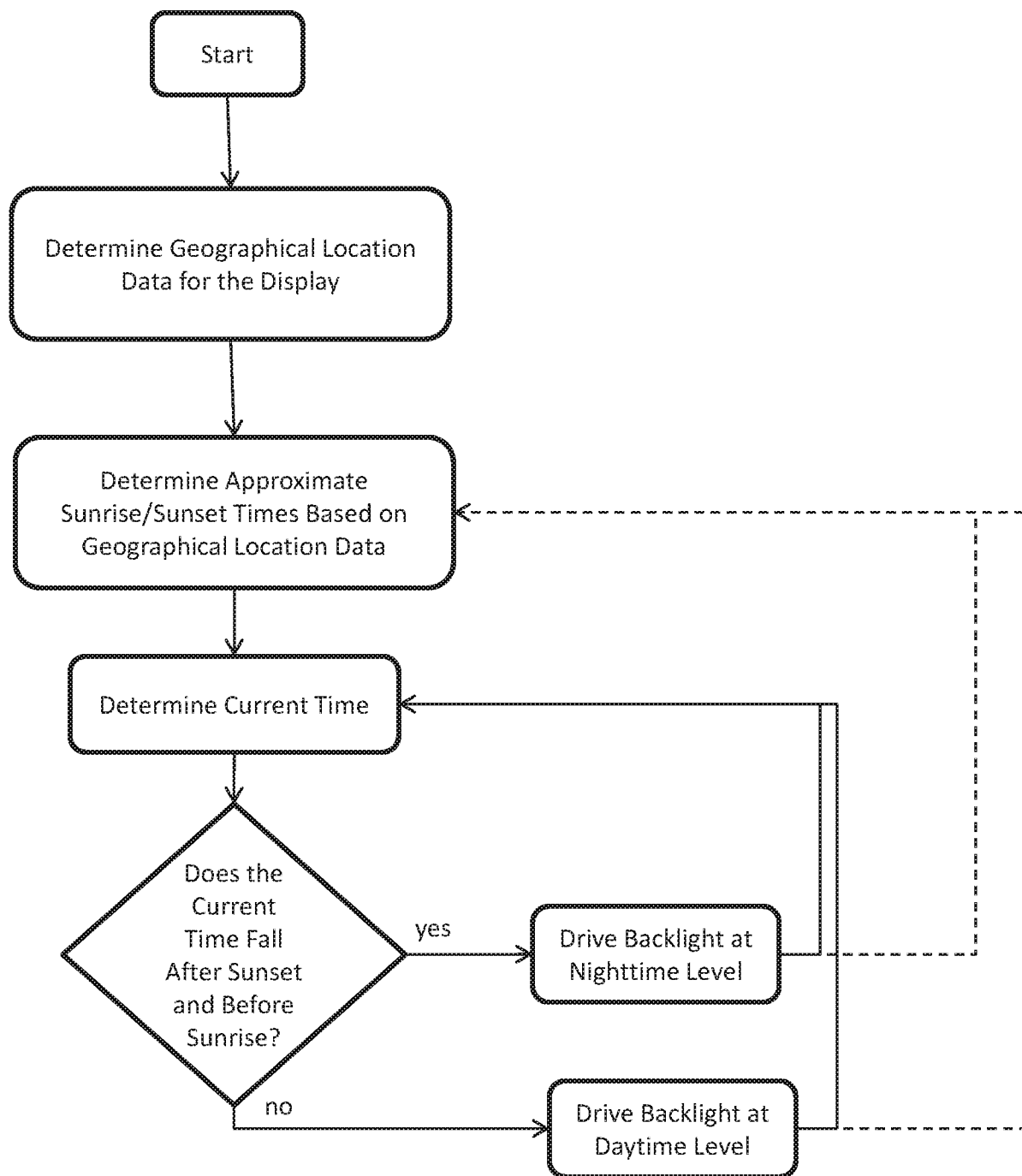


FIG-2

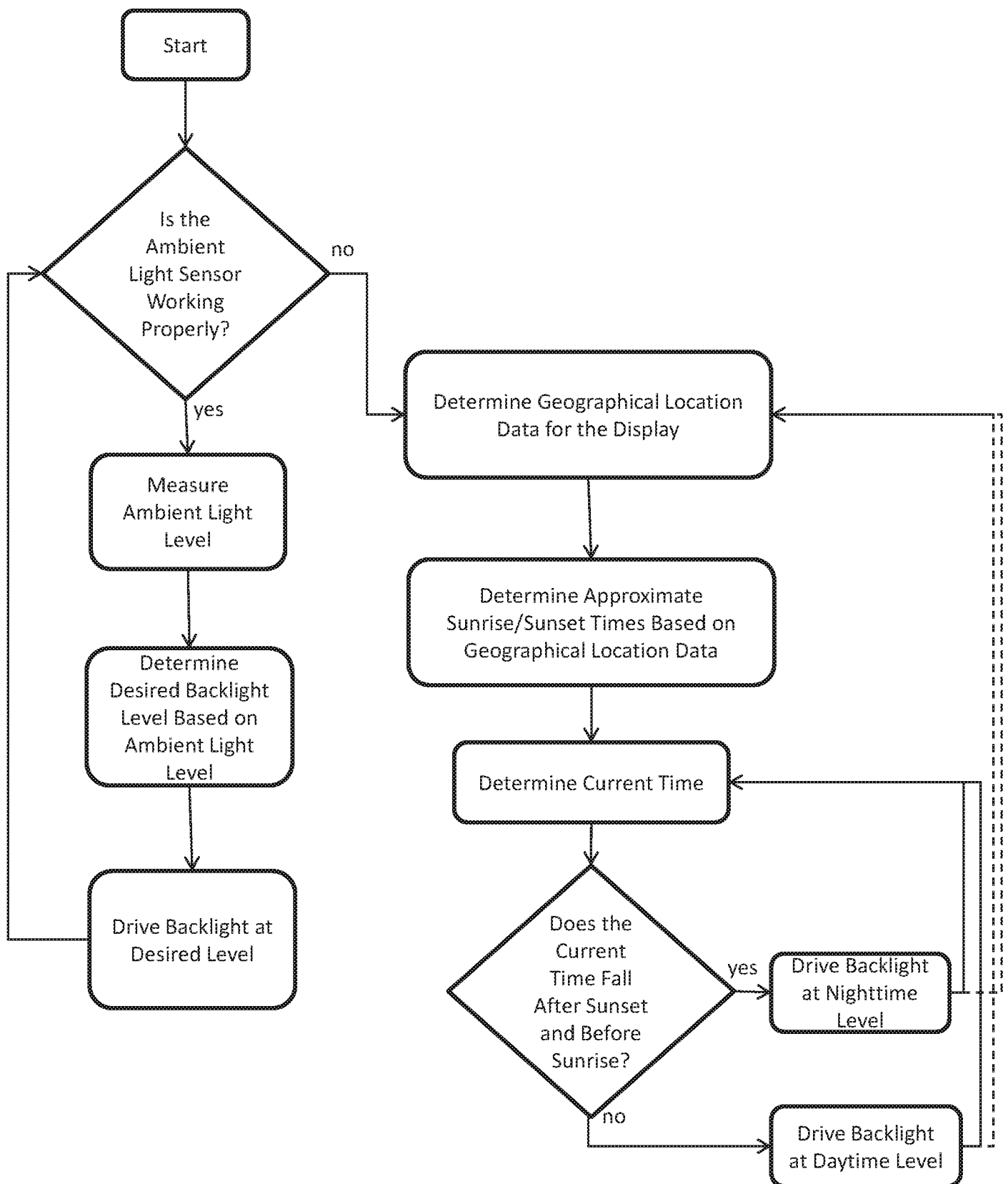


FIG-3

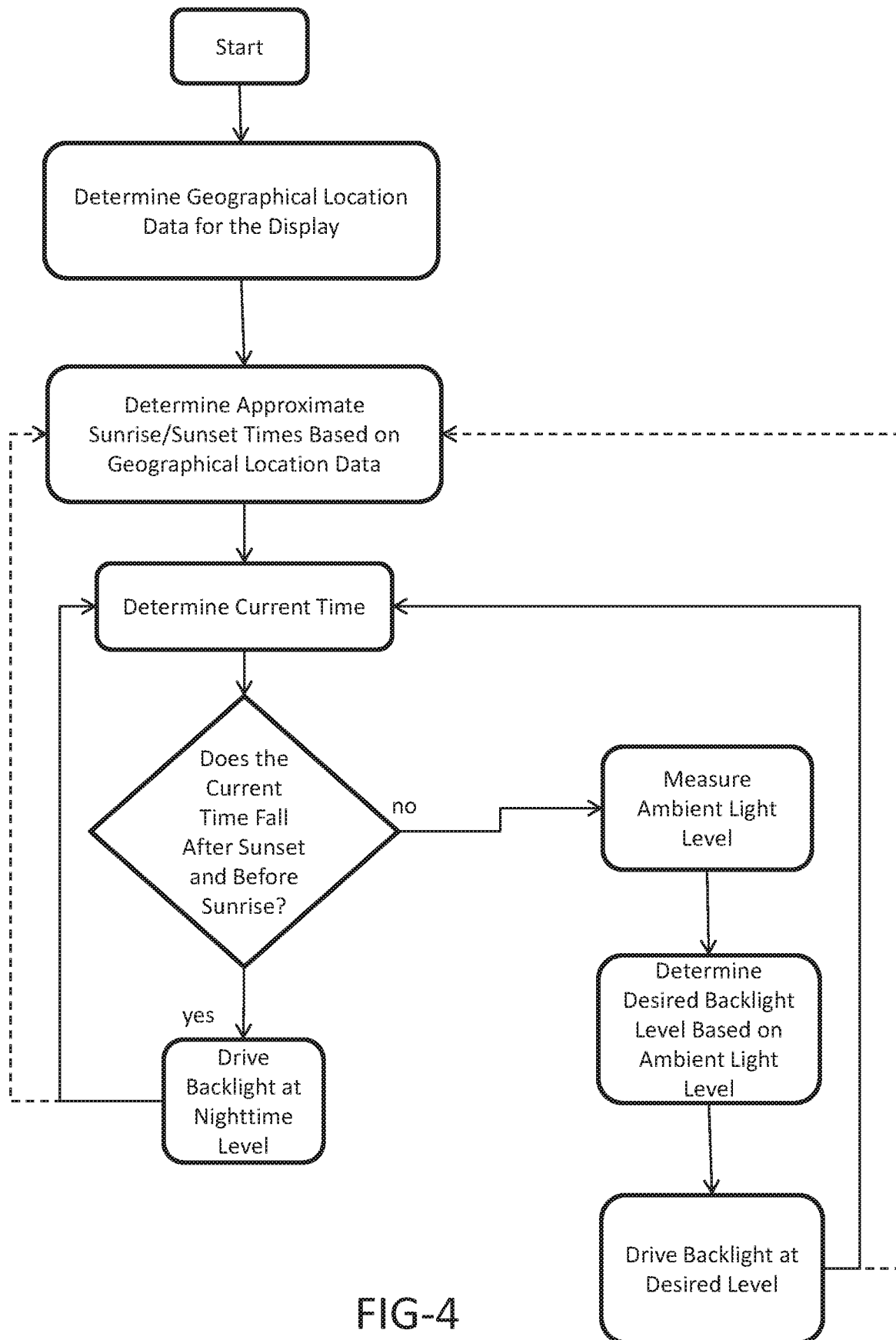


FIG-4

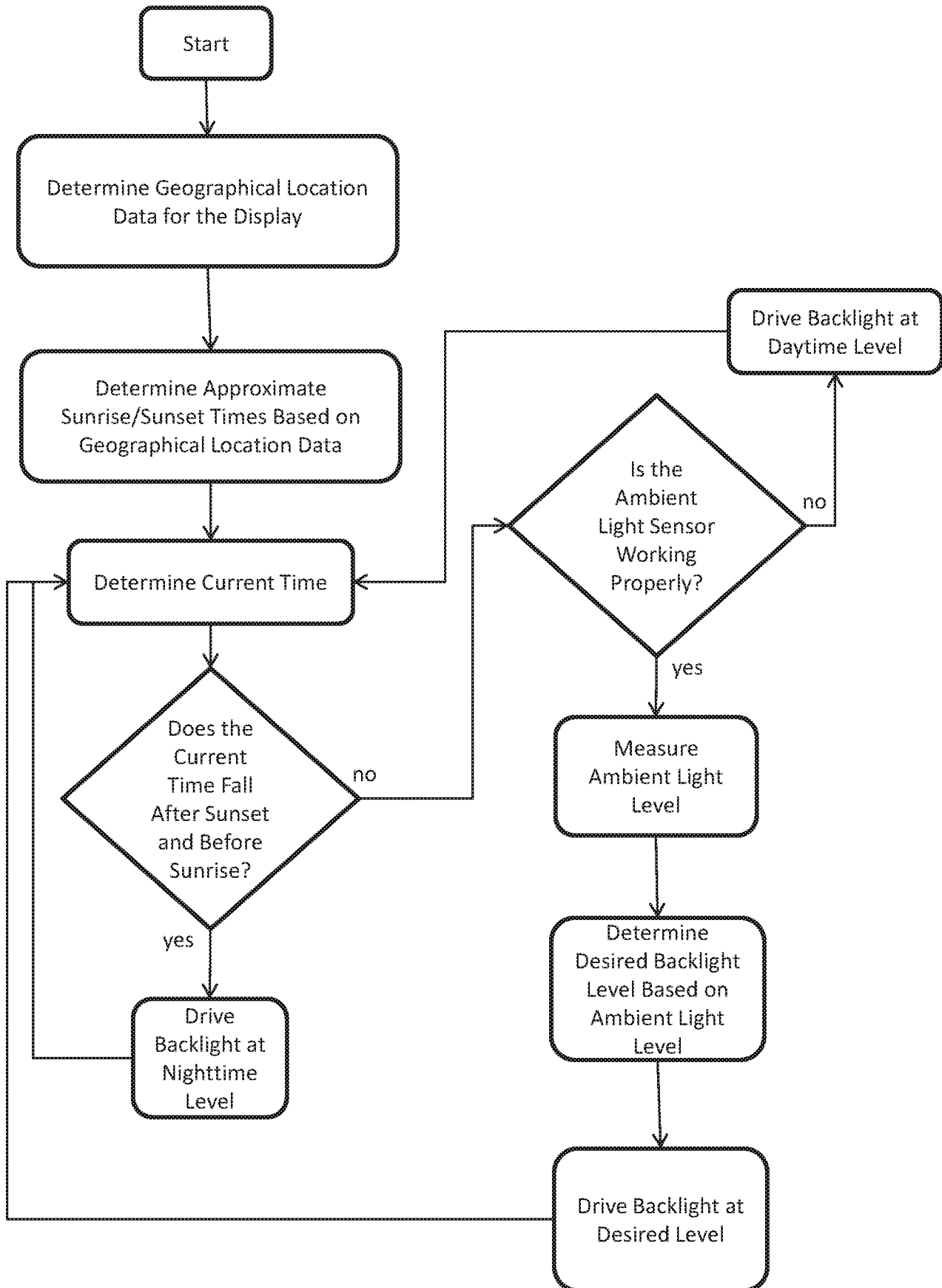


FIG-5

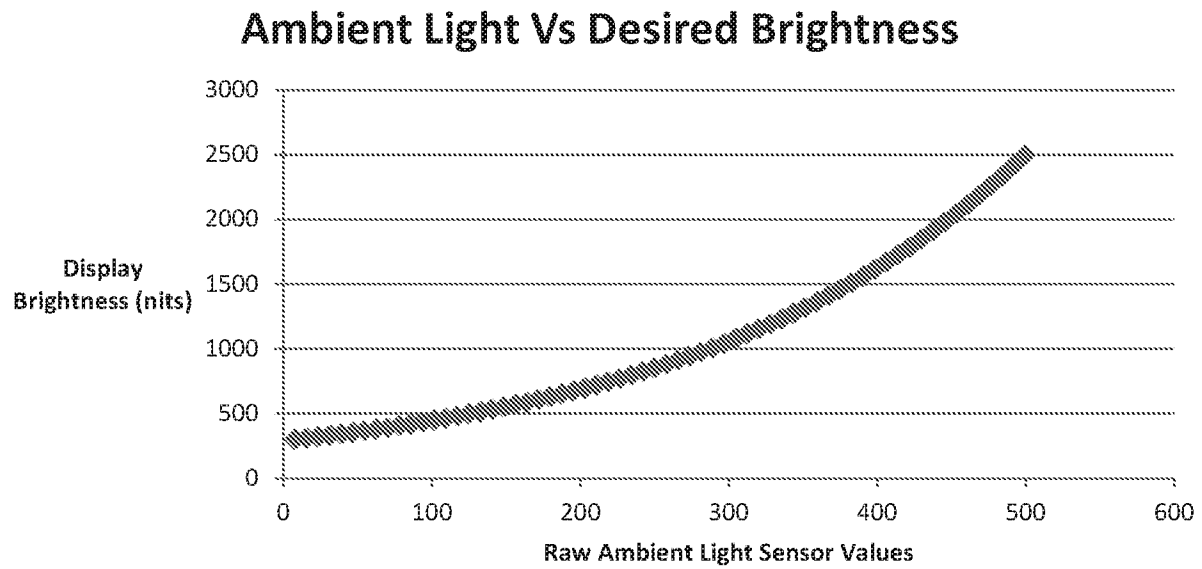


FIG-6

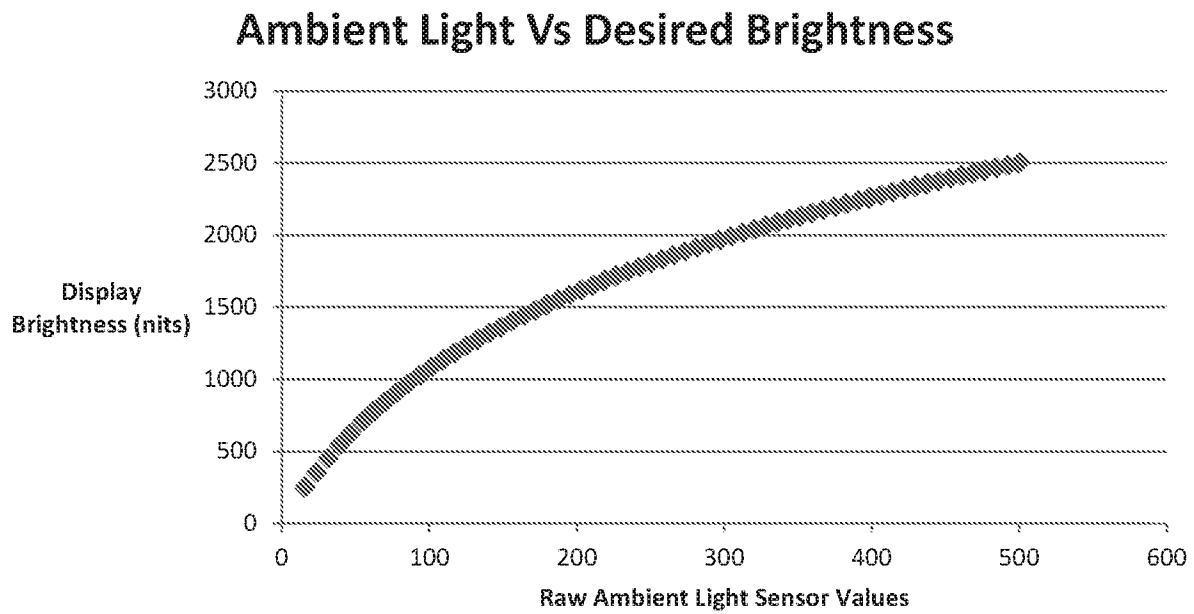


FIG-7

FIG-8

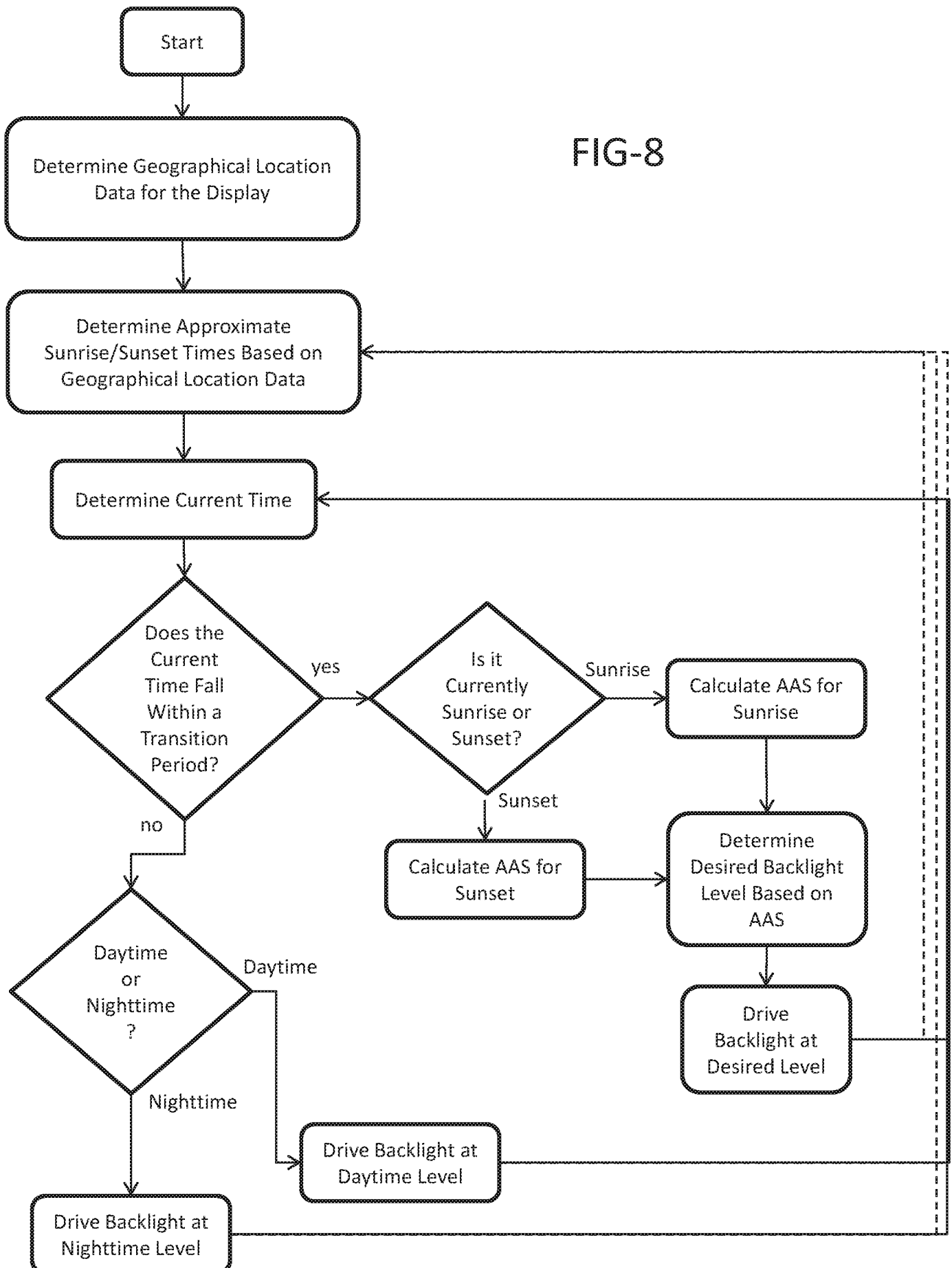


FIG-9

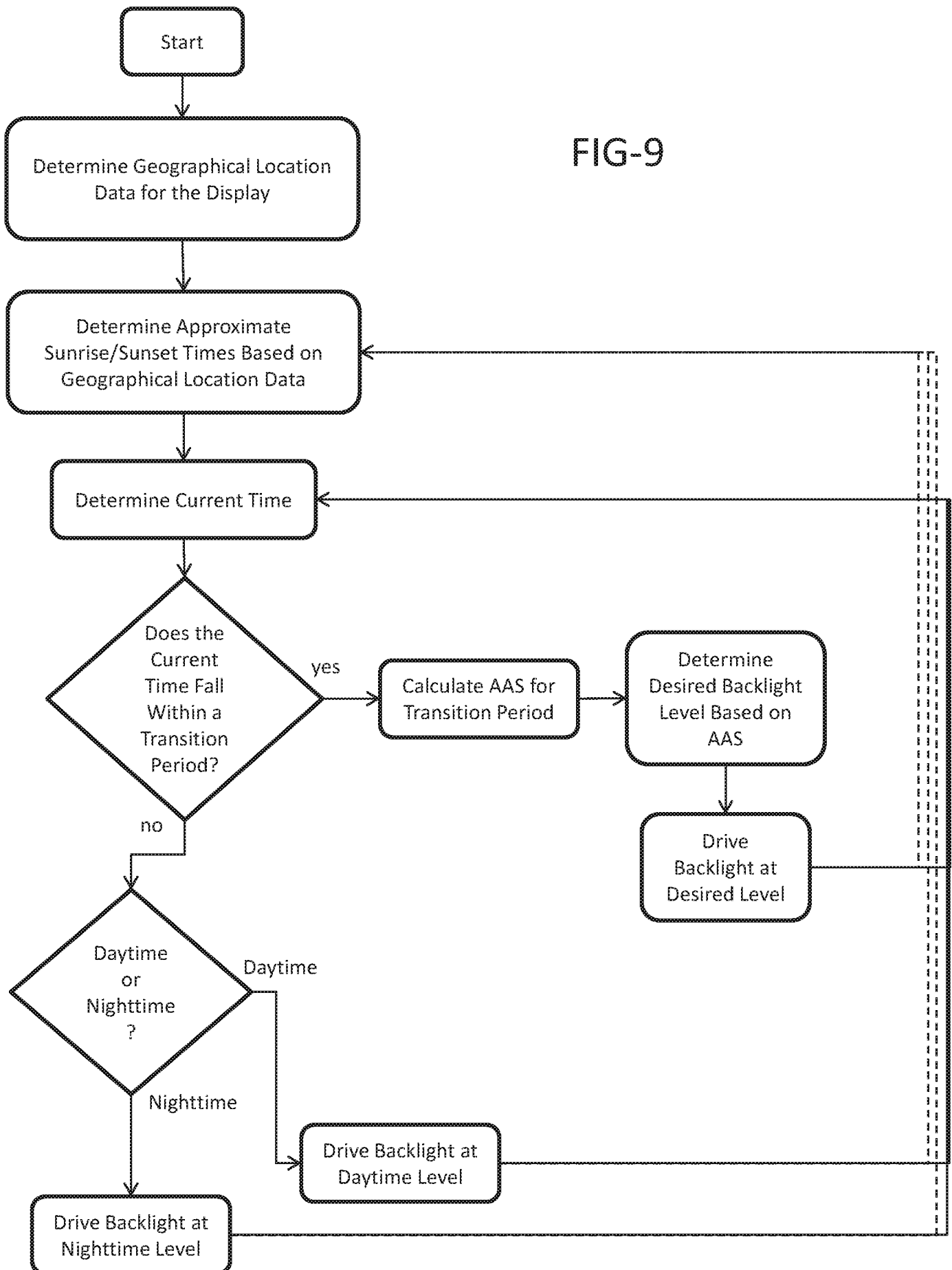
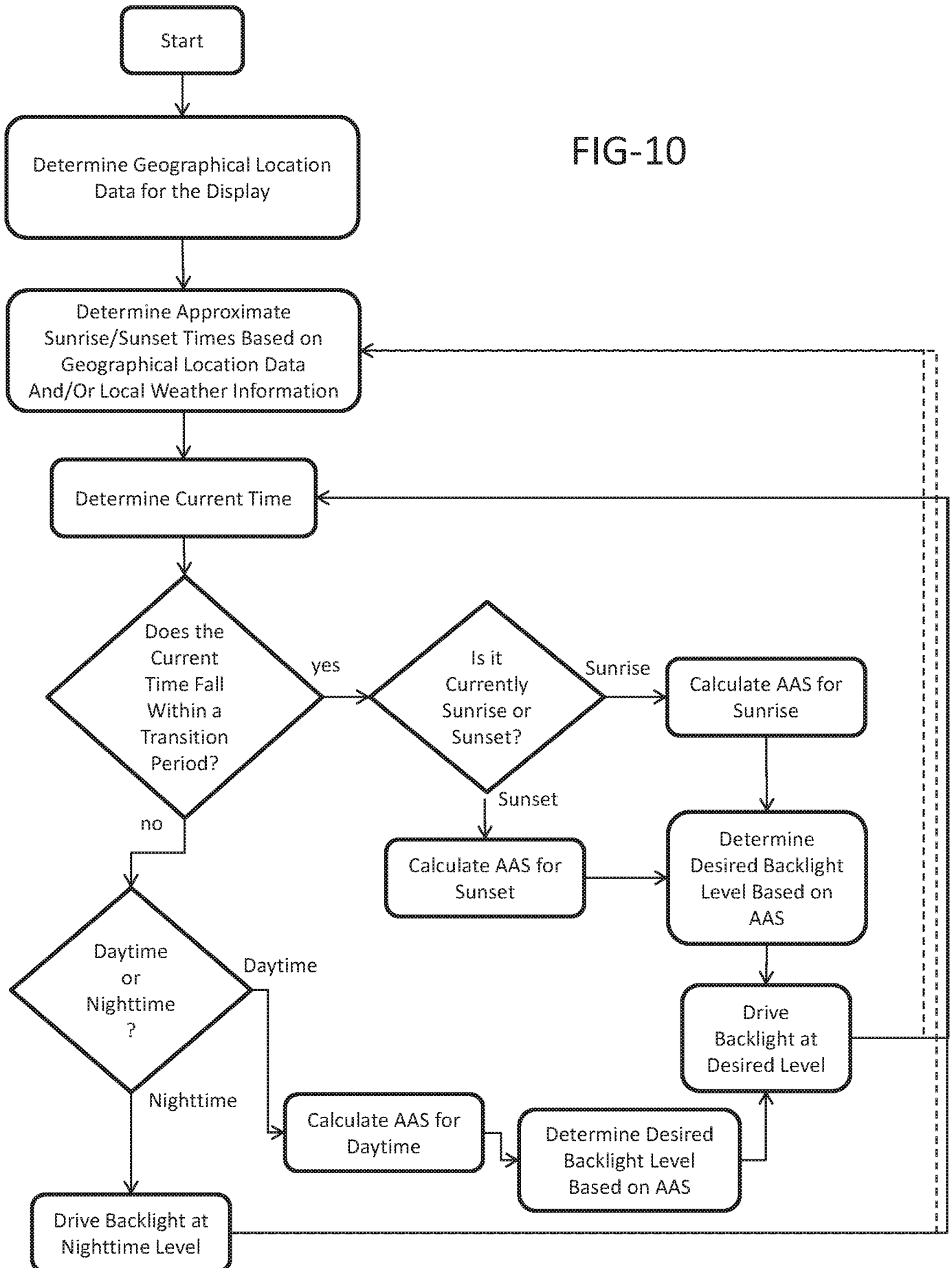


FIG-10



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2016/032692

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - G09G 3/36; G02F 1/1335 (2016.01)

CPC - G09G 3/3406; G09G 2320/064; G09G 2320/0646; G09G 2330/021; G09G 2360/16 (2016.05)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC - G09G 3/36; G02F 1/1335

CPC - G09G 3/3406; G09G 2320/064; G09G 2320/0646; G09G 2330/021; G09G 2360/16; H04M 1/22; H04M 1/72566; H04M 1/72572
H04W 52/0216; H04W 52/027; Y02B 60/50

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

USPC - 315/307; 345/87; 345/88; 345/102; 345/204; 345/207; 345/211; 345/690; 349/61; 349/68 (keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Orbit, Google Patents, Google Scholar, Google

Search terms used: display, liquid crystal display, lcd, backlight, sensor, detector, controller, processor, microprocessor, dusk, dawn, nighttime, daytime, dark, sunrise, sunset, power, voltage, current, provider, module, supply, ambient, environment

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6,388,388 B1 (WEINDORF et al) 14 May 2002 (14.05.2002) entire document	1-3, 6, 7, 9-13, 16, 17, 21-27, 29-33, 36, 37, 41-43, 46, 48
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Y		4, 5, 8, 14, 15, 18-20, 28, 34, 35, 38-40, 44, 45, 47
Y	US 2008/0078921 A1 (YANG et al) 03 April 2008 (03.04.2008) entire document	4, 5
Y	US 2009/0278766 A1 (SAKO et al) 12 November 2009 (12.11.2009) entire document	8, 14, 15, 28, 34, 35
Y	US 6,753,842 B1 (WILLIAMS et al) 22 June 2004 (22.06.2004) entire document	18-20, 38-40, 44
Y	US 2013/0098425 A1 (AMIN et al) 25 April 2013 (25.04.2013) entire document	19, 20, 39, 40, 45, 47
A	US 2011/0163691 A1 (DUNN) 07 July 2011 (07.07.2011) entire document	1-48
A	US 2012/0176420 A1 (LIU) 12 July 2012 (12.07.2012) entire document	1-48
A	US 2014/0002747 A1 (VOXX INTERNATIONAL CORPORATION) 02 January 2014 (02.01.2014) entire document	1-48
A	US 2011/0032285 A1 (YAO et al) 10 February 2011 (10.02.2011) entire document	1-48

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

11 August 2016 (11.08.2016)

Date of mailing of the international search report

02 SEP 2016

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