



US008743335B2

(12) **United States Patent**
Gettemy et al.

(10) **Patent No.:** **US 8,743,335 B2**
(45) **Date of Patent:** **Jun. 3, 2014**

(54) **DISPLAY HAVING A PLURALITY OF DRIVER INTEGRATED CIRCUITS**

(75) Inventors: **Shawn R. Gettemy**, San Jose, CA (US);
Carlin J. Vieri, Redwood City, CA (US); **Yongman Lee**, Pleasanton, CA (US); **Wei H. Yao**, Palo Alto, CA (US)

(73) Assignee: **Apple Inc.**, Cupertino, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/620,014**

(22) Filed: **Sep. 14, 2012**

(65) **Prior Publication Data**

US 2013/0009899 A1 Jan. 10, 2013

Related U.S. Application Data

(62) Division of application No. 12/236,066, filed on Sep. 23, 2008, now Pat. No. 8,325,309.

(51) **Int. Cl.**
G02F 1/1345 (2006.01)

(52) **U.S. Cl.**
USPC **349/152**; 349/151

(58) **Field of Classification Search**
USPC 349/149–152; 345/103
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,436,745 A 7/1995 Voisin et al.
6,937,216 B1 8/2005 Ishiyama

7,375,787 B2	5/2008	Cheng et al.	
8,525,822 B2 *	9/2013	Liu et al.	345/98
2002/0072141 A1	6/2002	Nakashima et al.	
2002/0158859 A1	10/2002	Nakano et al.	
2004/0090435 A1 *	5/2004	Kim	345/204
2005/0168491 A1	8/2005	Takahara et al.	
2006/0103641 A1	5/2006	Marhefka	
2007/0247582 A1	10/2007	Mochizuki	
2007/0257890 A1	11/2007	Hotelling et al.	
2008/0130867 A1	6/2008	Bowen	
2008/0143660 A1	6/2008	Itou	
2008/0158177 A1	7/2008	Wilson et al.	
2008/0211985 A1	9/2008	Igarashi et al.	

FOREIGN PATENT DOCUMENTS

EP	1909132	4/2008
JP	2007142387	6/2007
WO	2006121914	11/2006

OTHER PUBLICATIONS

Susumu Nakakarumai, General Manager Display Systems Division; NEC Electronics LCD Driver IC Technology for Next-Generation Large-Screen LCD TVs; vol. 61, Dec. 1, 2006.

* cited by examiner

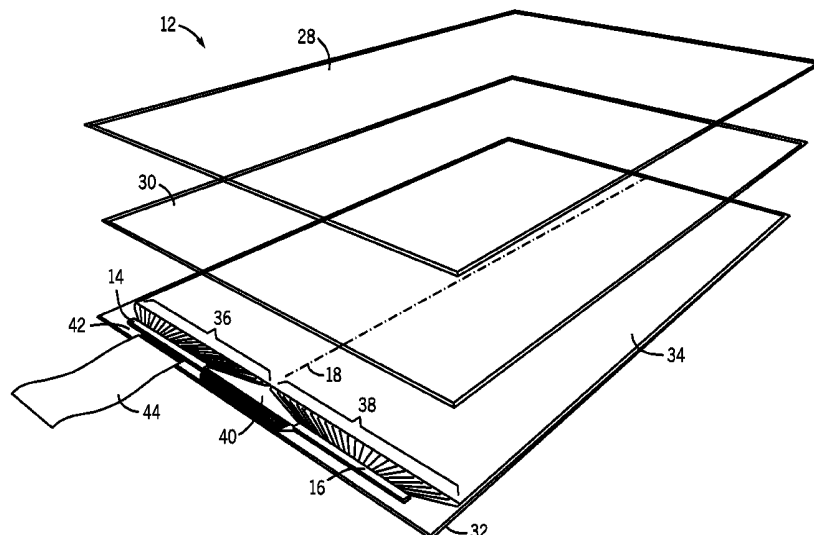
Primary Examiner — Dung Nguyen

(74) *Attorney, Agent, or Firm* — Fletcher Yoder PC

(57) **ABSTRACT**

An electronic device is disclosed. In some embodiments, the electronic device includes a liquid-crystal display (LCD) and a plurality of driver integrated circuits (ICs) coupled to the LCD. The driver ICs may be disposed near non-central locations along a side of the LCD, and in some embodiments, one of the driver ICs may be a master driver IC and the other driver IC or driver ICs may be slave driver ICs.

20 Claims, 6 Drawing Sheets



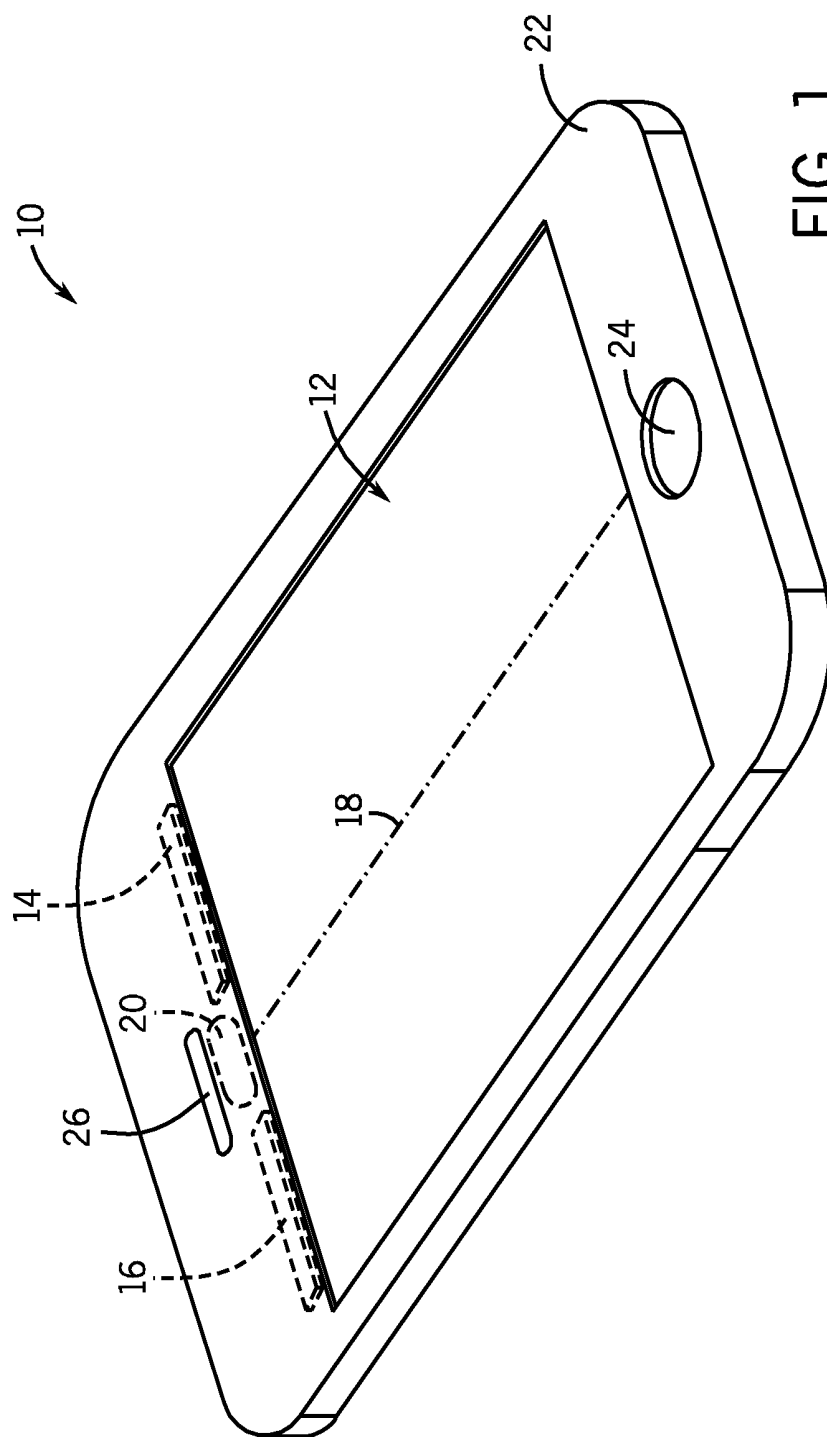


FIG. 1

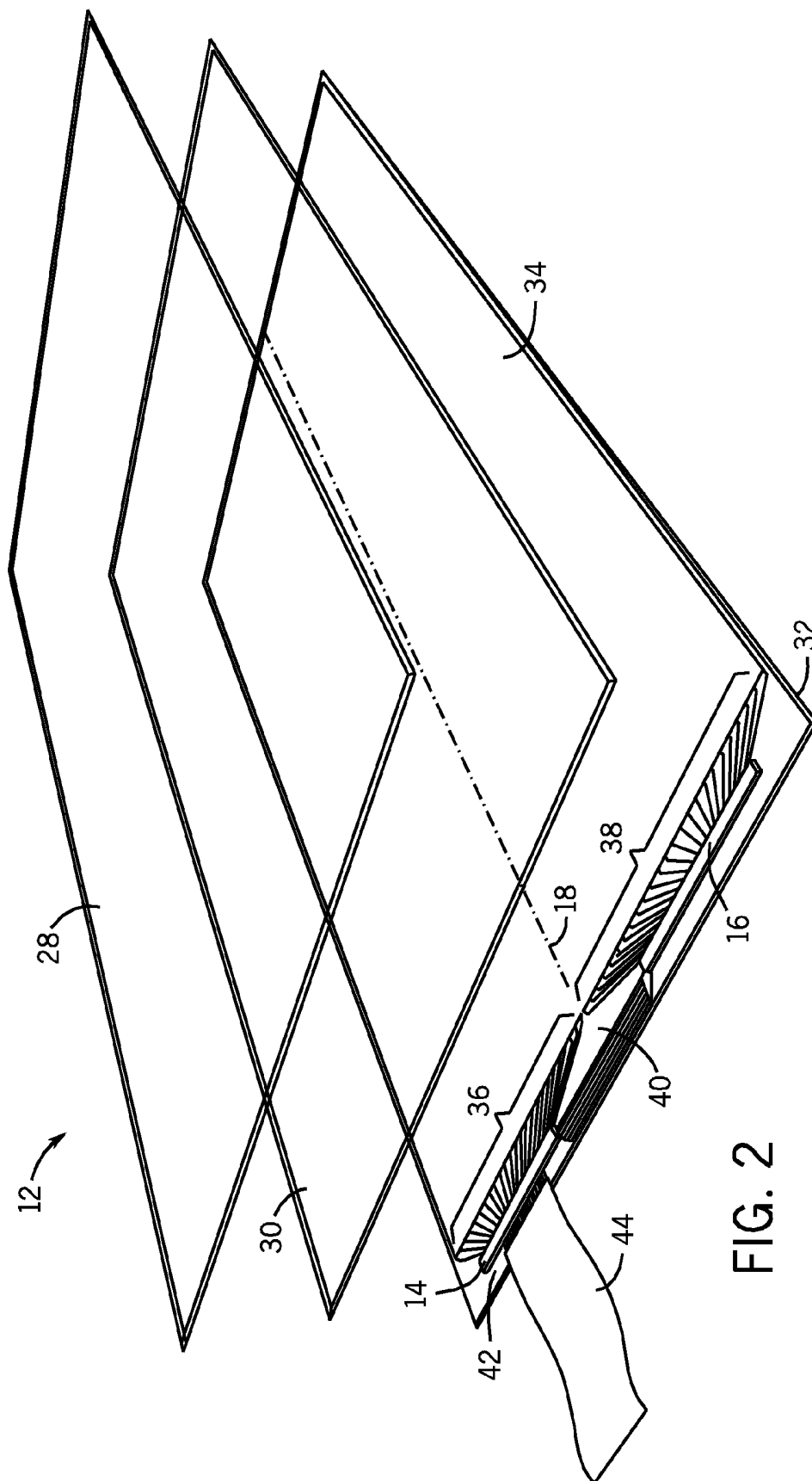


FIG. 2

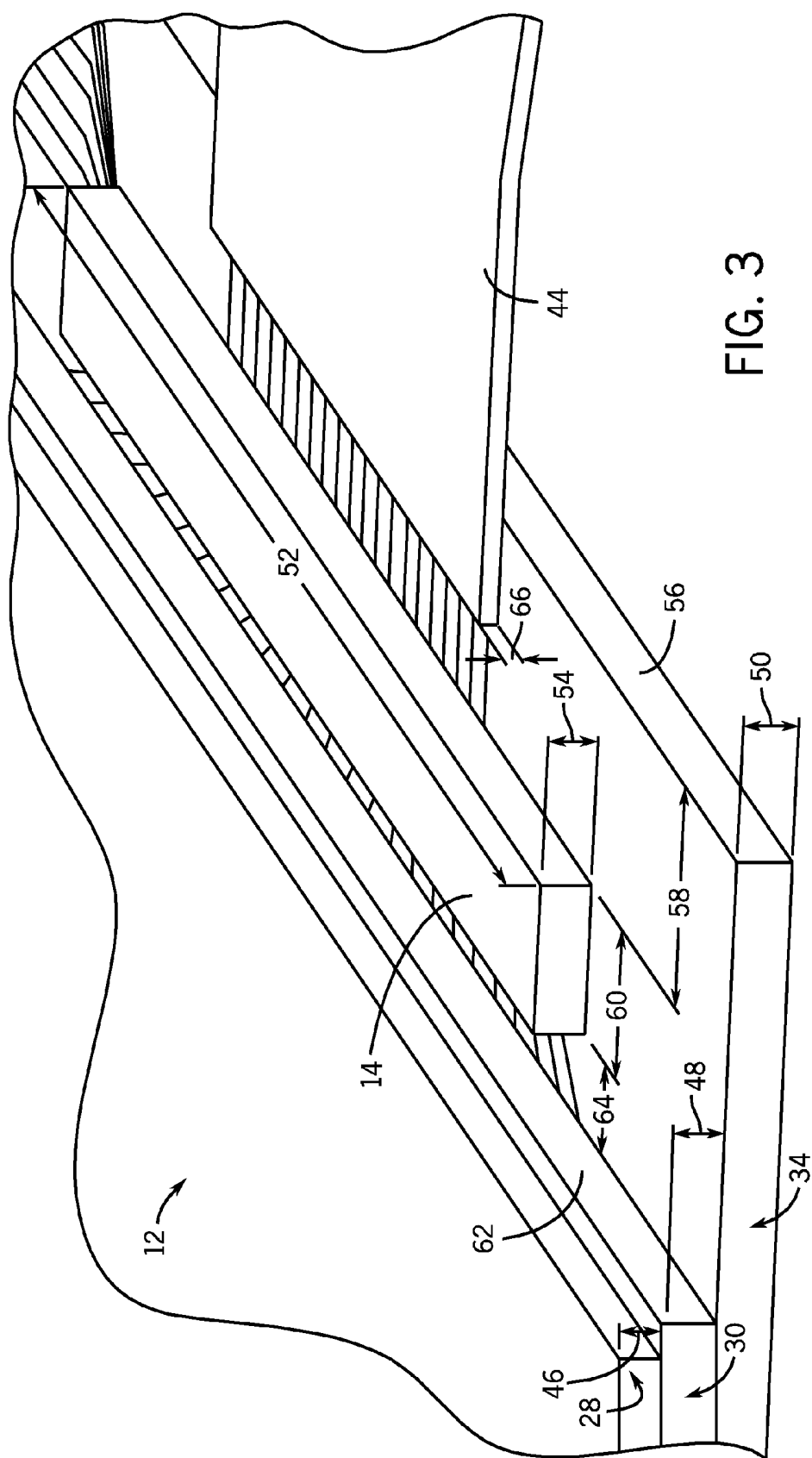


FIG. 3

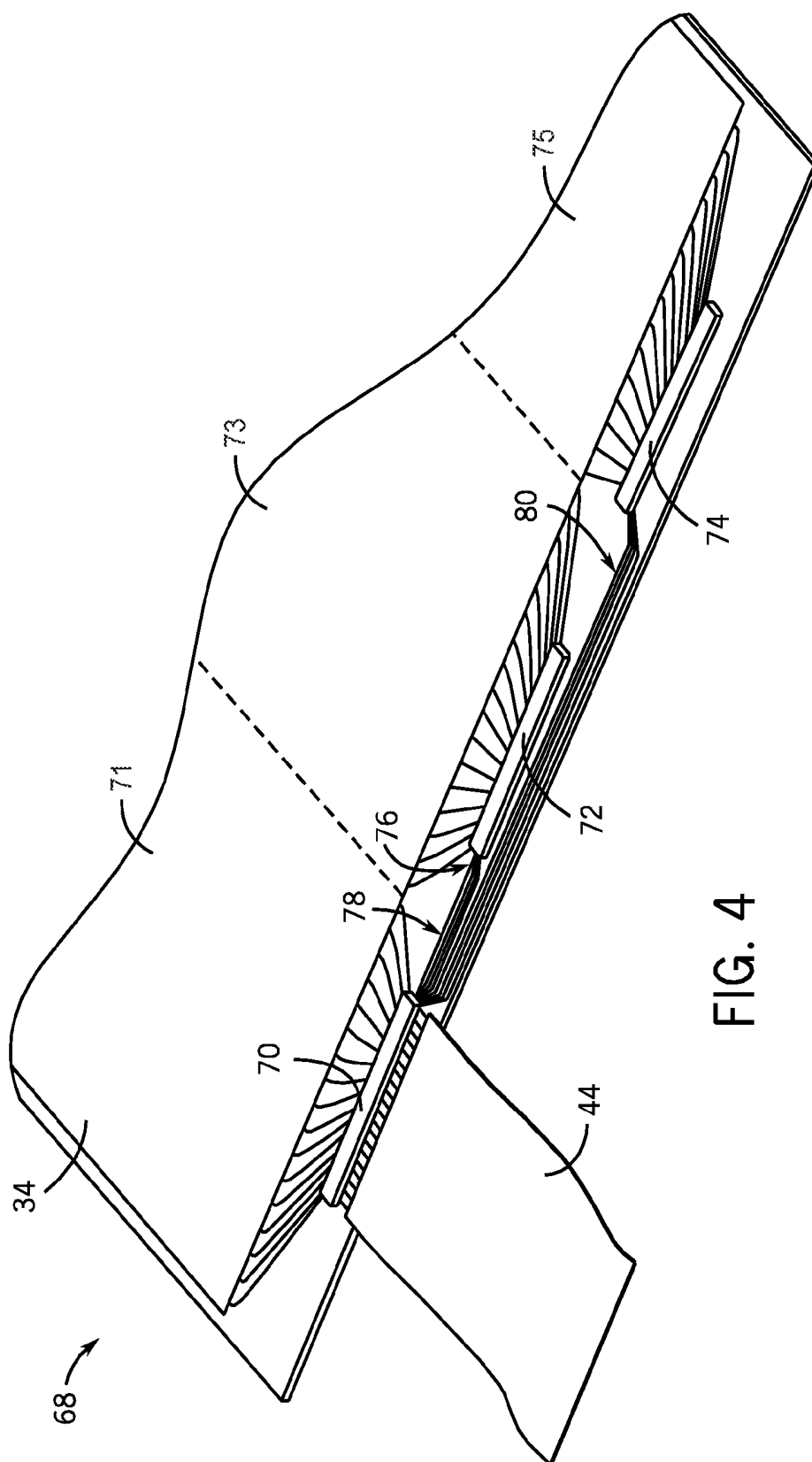
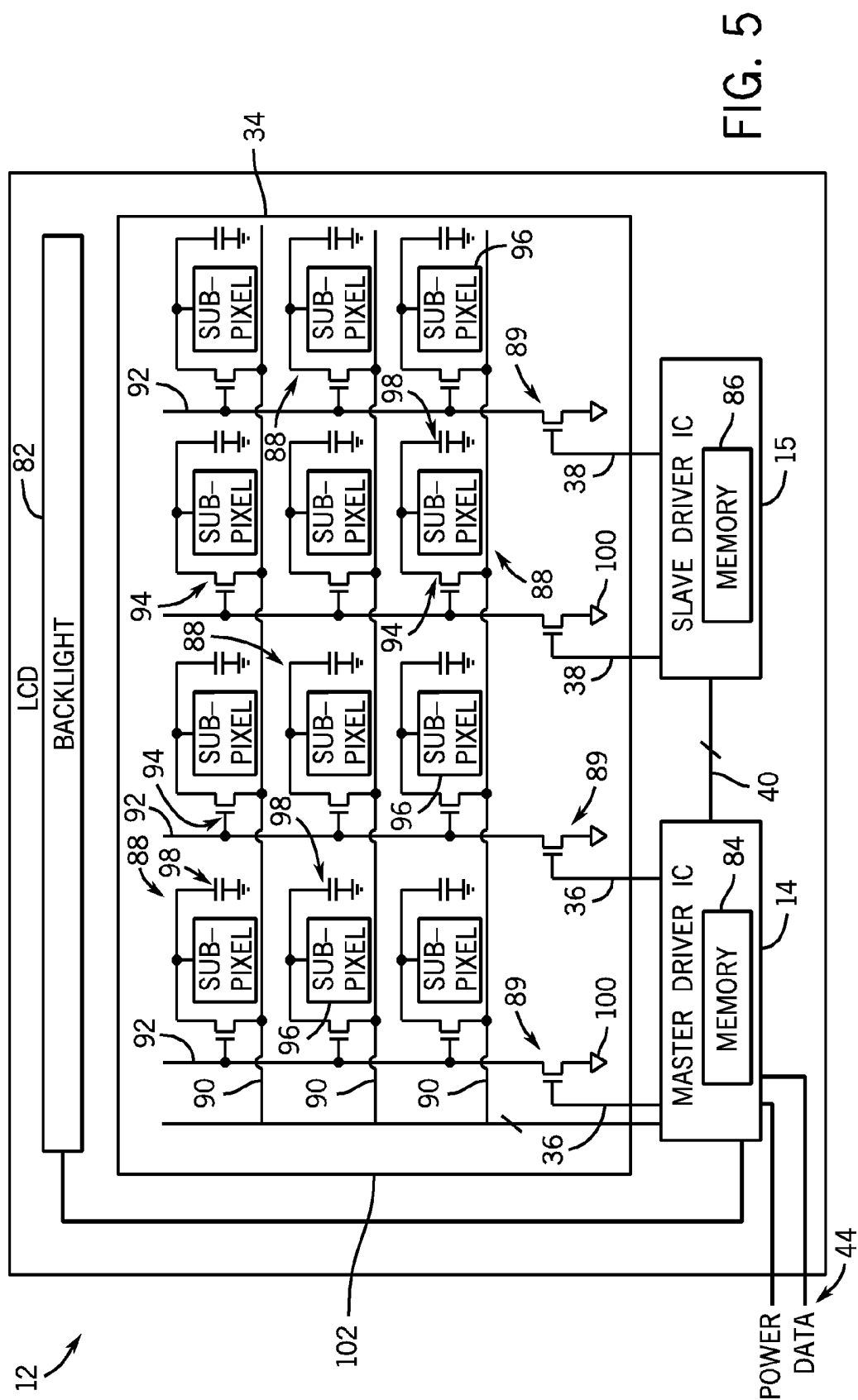


FIG. 4



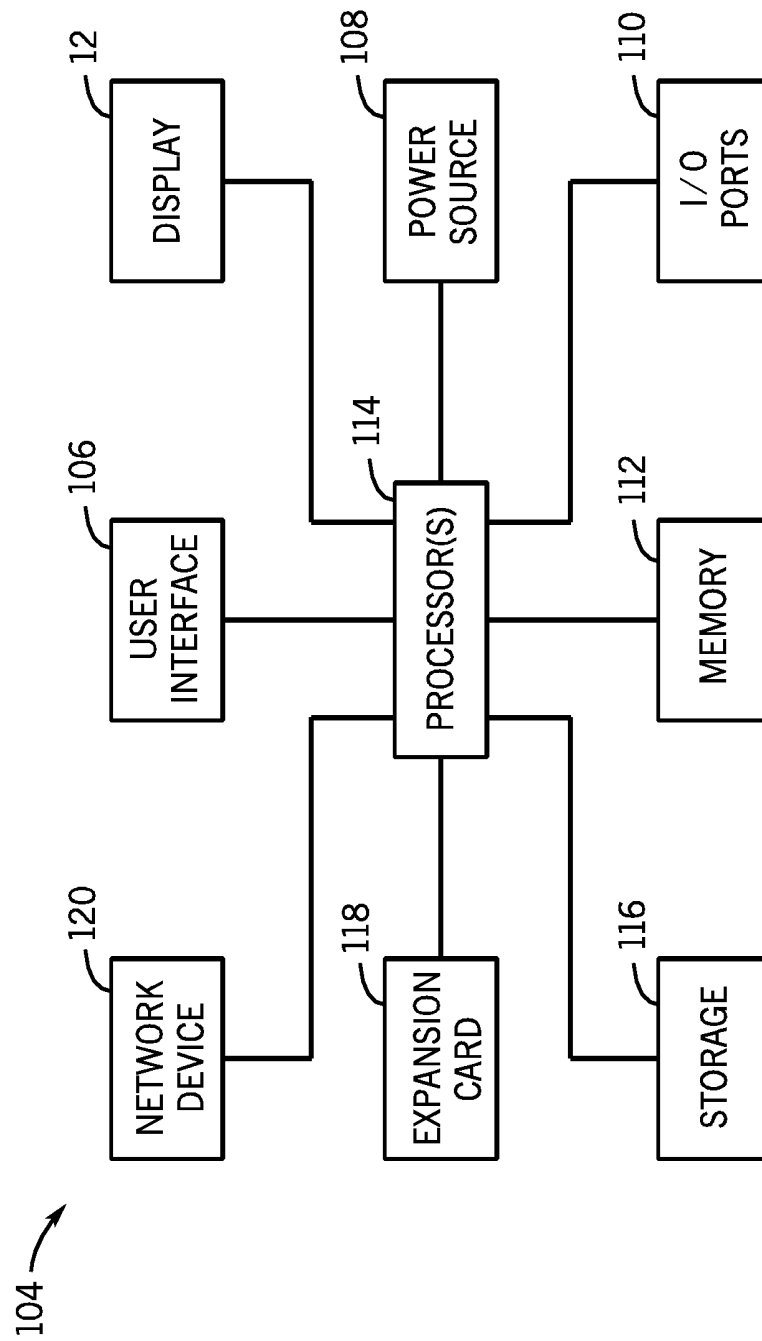


FIG. 6

DISPLAY HAVING A PLURALITY OF DRIVER INTEGRATED CIRCUITS

CROSS REFERENCE TO RELATED APPLICATIONS

The present application is a continuation of U.S. patent application Ser. No. 12/236,066, entitled "Display Having a Plurality of Driver Integrated Circuits", filed Sep. 23, 2008, which is herein incorporated by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to displays and, in some embodiments, to displays having a plurality of integrated circuits.

2. Description of the Related Art

This section is intended to introduce the reader to various aspects of art that may be related to various aspects of the present invention, which are described and/or claimed below. This discussion is believed to be helpful in providing the reader with background information to facilitate a better understanding of the various aspects of the present invention. Accordingly, it should be understood that these statements are to be read in this light, and not as admissions of prior art.

Liquid-crystal displays (LCDs) are used in a variety of electronic devices, such as televisions, computer monitors for desktop and laptop computers, and specialized equipment like automated teller machines, medical devices, and industrial equipment. LCD panels are also frequently used in portable electronic devices, such as cell phones, global-positioning-satellite (GPS) units, and hand-held media players.

Typically, LCDs include an array of pixels for displaying images. The pixels often each include three or more sub-pixels each for displaying a color, e.g., red, blue, green, and in some instances, white light. To display an image, the appropriate sub-pixels on the display are rendered transmissive to light, allowing color-filtered light to pass through each of the transmissive sub-pixels and form an image.

Before image data is rendered by an LCD, the data is often passed through a driver integrated circuit (driver IC). Image data often includes pixel locations and pixel intensities. Driver ICs receive image data from other portions of the electronic device, such as a graphics card or graphics controller. Based on the received data, the driver ICs output control signals that change the transmissive state of the appropriate sub-pixels. Often, the signals that convey the image data to the driver IC are weaker (e.g., lower voltage or lower current) than the control signals. The driver ICs often include circuitry to boost the signal strength of the image data and, in some instances, circuitry to convert digital image data signals to analog control signals. Additionally, driver ICs often route image data to the appropriate rows and columns of sub-pixels. The driver ICs interpret the pixel locations and route the pixel intensities to the appropriate rows and columns.

Driver ICs often occupy space around an LCD panel that could be put to other uses. Frequently, driver ICs are disposed near the middle of the edges of LCD panels. This is done to reduce the distance that signals travel from the driver ICs to each side of the LCD panel, but as a result, space that might otherwise be used for other components of the electronic device is occupied by driver ICs. In particular, it is often desirable to position certain sensors, buttons, speakers, or other components near the middle of the edge of LCDs, but disadvantageously driver ICs often consume this area.

Shifting the position of driver ICs is complicated by the deterioration of control signals over a distance. A driver IC disposed to one side of an LCD's edge, e.g., near a corner, may transmit signals to pixels near the other side of the LCD.

These signals may travel over a longer distance than those from a centrally disposed LCD. The signals may deteriorate over the longer distance due to resistance, capacitive coupling, and inductive coupling. This effect may be particularly prevalent in amorphous silicon LCDs, which may be less expensive to manufacture, but include may include increased numbers of lines between the driver IC and pixels, and increased space needed for routing, when compared to other types of higher cost LCDs.

BRIEF SUMMARY

Systems, methods, and devices are disclosed, including a device having a liquid-crystal display (LCD) panel that includes a plurality of driver ICs. The driver ICs may be mounted along a side of the LCD panel near non-central portions of the side. In some embodiments, the driver ICs have a master-slave relationship with one of the driver ICs distributing power and data to the other driver IC or driver ICs.

BRIEF DESCRIPTION OF THE DRAWINGS

Advantages of the invention may become apparent upon reading the following detailed description and upon reference to the drawings in which:

FIG. 1 illustrates an electronic device in accordance with an embodiment of the present technique;

FIG. 2 illustrates an LCD in accordance with an embodiment of the present technique;

FIG. 3 illustrates additional details of the LCD of FIG. 2;

FIG. 4 illustrates an LCD in accordance with another embodiment of the present technique;

FIG. 5 is a schematic representation of an LCD in accordance with an embodiment of the present technique; and

FIG. 6 illustrates a system in accordance with an embodiment of the present technique.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

One or more specific embodiments of the present invention will be described below. In an effort to provide a concise description of these embodiments, not all features of an actual implementation are described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

FIG. 1 illustrates an embodiment of an electronic device 10 having an LCD 12 including two driver ICs 14 and 16. The two driver ICs 14 and 16 may be spaced away from a longitudinal central axis 18 of the LCD 12. As a result, in some embodiments, an area 20 between the driver ICs 14 and 16 may be occupied by other components of the electronic device 10, such as a button, a speaker, a microphone, a camera, or other electronic component. Further, because the

driver ICs **14** and **16** are positioned closer to the portions of the LCD that they service, the driver ICs may transmit signals to portions of the LCD over relatively short distances relative to a single driver IC. The driver ICs **14** and **16** and the LCD **12** are described in detail below, after describing other aspects of the electronic device **10**.

The illustrated electronic device **10** may be a hand-held electronic device, such as a personal media player, a cellular telephone (e.g., a “smart phone”), a GPS unit, a handheld gaming device, a personal digital assistant, or a combination thereof (which is not to suggest that the term “or” is used herein to refer to exclusive alternatives, unless otherwise indicated). Other examples of electronic devices and other systems that may include the LCD **12** are described below with reference to FIG. **6**.

The electronic device **10** may include a body **22**, a power button **24**, and a speaker **26**. The body **22** may be made of metal, plastic, or other appropriate materials. The body **22** may generally shield the interior of the electronic device **10** from electromagnetic noise, moisture, and mechanical contact. The power button **24** may be generally centrally located along the longitudinal central axis **18** along with the speaker **26**. The electronic device **10** may include ports (not shown) for coupling the electronic device **10** to a power supply, a SIM card, a memory card, or other inputs. Additionally, the electronic device **10** may include various interfaces for receiving input from a user, interfaces such as a transparent touch screen (e.g., a mutual capacitance multi-touch sensor) disposed adjacent the LCD **12**, a keypad, an accelerometer, an image sensor, or a microphone.

FIG. **2** illustrates additional details of the LCD **12**. The LCD **12** may be any of a variety of types of LCDs, including a twisted nematic (TN) panel, an in-plane switching (IPS) panel, a multi-domain vertical alignment (MVA) panel, a patterned vertical alignment (PVA) panel, or a super patterned vertical alignment (S-PVA) panel, for example. In other embodiments, other types of displays may be used, such as a plasma display, an organic light emitting diode display, an electronic ink display, or other displays having drivers.

The LCD **12** may include a polarizer **28**, a color filter **30** and a substrate **32**. The polarizer **28** may be disposed above the color filter **30** and may be configured to selectively transmit light having a particular orientation. The color filter **30** may be made of glass or other appropriate materials, e.g., translucent or transparent plastic. The color filter **30** may include a patterned matrix of color filters arrayed according to the position of sub-pixels on the LCD **12** (examples of which are described below with reference to FIG. **5**). For example, the color filter **30** may include a plurality of pixel color filters each having a region that transmits red light and obstructs other frequencies, a region that transmits green light and obstructs other frequencies, and a region that transmits blue light and obstructs other frequencies.

The substrate **32** may include a pixel array **34**, first and second groups of fanout traces **36** and **38**, inter-driver bus traces **40**, input traces **42**, and a flex cable **44**. The first group of fanout traces **36** may connect the driver IC **14** to column lines in the left half of the pixel array **34**, and the second group of fanout traces **38** may connect the driver IC **16** to column lines in the right half of the pixel array **34**. The inter-driver bus traces **40** may connect the driver IC **14** to the driver IC **16**, and the input traces **42** may connect the flex cable **44** to the driver IC **14**.

Some or all of the fanout traces **36** and **38**, the inter-driver bus traces **40**, and the input traces **42** may be integrally formed on the substrate **32** along with the features of the pixel array **34**. For instance, these features **36**, **38**, **40**, and **42** may

be formed with semiconductor processing steps, e.g., by thin-film deposition of conductive materials followed by photolithographic patterning and etching. In some embodiments, the illustrated features **36**, **38**, **40**, and **42** are formed from a conductive metal film that is deposited on the substrate **32** and selectively etched to form the features **36**, **38**, **40**, and **42**, or the features **36**, **38**, **40**, and **42** may be formed from doped semiconductive materials, such as doped amorphous silicon or doped low-temperature polysilicon.

The features **36**, **38**, **40**, and **42** may be formed concurrent with portions of the pixel array **34**. The pixel array **34** may include a plurality of transistors formed from semiconductive materials, such as amorphous silicon or low-temperature polysilicon. Connections between the transistors may be formed from the same conductive film used to form the traces **36**, **38**, **40**, and **42**. Examples of the transistors and other features of the pixel array are described below with reference to FIG. **5**.

The driver ICs **14** and **16** may be connected to the traces **36**, **38**, **40**, and **42** through a ball grid array, wire bonding, wave soldering or other techniques known in the art. In some embodiments, the driver ICs **14** and **16** may be mounted directly to the LCD **12**, without an intervening flex tape, or they may be coupled to the LCD **12** with a flex tape or other intervening structure. The flex cable **44** may connect the LCD **12** to other portions of the electronic device **10** (FIG. **1**) and convey image data and power to the LCD **12**.

While the driver ICs **14** and **16** may be generally similar or identical to each other, in some embodiments, they may have different roles. For example, the driver IC **14** may function as a master driver IC, and the driver IC **16** may function as a slave driver IC. The term “master driver IC” refers to a driver IC that distributes data to other driver ICs, and the term “slave driver IC” refers to driver ICs that receive that data. Commands, image data, and power intended for the driver IC **16** may be transmitted from or through the driver IC **14** by way of the inter-driver bus traces **40**.

Each of the driver ICs **14** and **16** may drive (e.g., modulate the transmissive state of) a plurality of pixels. In some embodiments, the pixel array **34** may include about 480 columns of pixels and about 720 rows of pixels. The columns may extend generally parallel to the longitudinal central axis **18**, and the rows may extend generally perpendicular to the longitudinal central axis **18**. Each driver IC **14** and **16** may drive about 240 columns of pixels, with each column of pixels having about three columns of sub-pixels. Each of the fanout traces **36** and **38** may drive one column of sub-pixels, or in some embodiments, the fanout traces **36** and **38** may each be connected to three columns of sub-pixels through a 1 to 3 multiplexer.

The inter-driver bus traces **40** may convey image data, power, and commands from the master driver IC **14** to the slave driver IC **16**. The inter-driver bus traces **40** may carry analog signals (e.g., voltage or current signals) that are representative of image data. Or, in some embodiments, the inter-driver bus traces **40** may carry digital signals that are converted to analog signals by the driver IC **16**.

The FIG. **3** illustrates additional details of the LCD **12** including certain dimensions. The polarizer **28** may have a thickness **46** of less than about 0.5 mm, e.g., between about 0.08 mm and about 0.25 mm. The color filter **30** may have a thickness **48** of less than about 0.5 mm, e.g., between about 0.1 mm and about 0.3 mm. The substrate **34** may have a thickness **50** of less than about 0.5 mm, e.g., between about 0.1 mm and about 0.3 mm. The driver ICs **14** (FIG. **3**) and **16** (FIG. **2**) may have a width **52** of less than about 25 mm, e.g., between about 12 mm and about 14 mm, and a height **54** of

less than about 0.5 mm, e.g., between about 0.1 and about 0.4 mm. The driver ICs 14 and 16 may be spaced away from a top edge 56 of the substrate 34 by a distance 58 that is less than about 2 mm, e.g., between about 0.8 and about 1.5 mm, or about 1.2 mm. The driver ICs 14 and 16 may have a width 60 that is less than about 1.5 mm, e.g., between about 0.5 and about 0.1 mm, or about 0.8 mm. The driver ICs 14 and 16 may be spaced away from a top edge 62 of the color filter 30 by a distance 64 of less than about 1 mm, e.g., between about 0.3 and about 0.7 mm, or about 0.5 mm. The pixel matrix 34 may be spaced less than about 3 mm from the edge 62, e.g., between about 1 and about 3 mm, or between about 1.7 mm and about 2 mm. The flex cable 44 may have a thickness 66 that is less than about 0.3 mm, e.g., about 0.1 mm. The distance between the driver ICs 14 and 16 may be greater than about 5 mm, e.g., between about 10 mm and about 14 mm or between about 11 mm and about 13 mm.

FIG. 4 illustrates another embodiment of an LCD 68. The illustrated LCD 68 may include three driver ICs 70, 72, and 74, whereby driver IC 70 corresponds to a first portion 71 of pixel array 34, driver IC 72 corresponds to a second portion 73 of pixel array 34, and driver IC 74 corresponds to a third portion of pixel array 34. The driver IC 70 may be characterized as the master driver IC, and the driver ICs 72 and 74 may be characterized as slave driver ICs. In this embodiment, a first portion 76 of an inter-driver bus 78 couples to the driver IC 72 and a second portion 80 of the inter-driver bus 78 couples to the other driver IC 74. In other embodiments, all of the traces in the inter-driver bus 78 may couple to both of the driver ICs 72 and 74, and data directed toward each of the driver ICs 72 or 74 may be multiplexed or otherwise addressed to each of the driver ICs 72 and 74. The master driver (e.g., IC 70) may determine whether image data is addressed to a first portion 71 of the pixel array 34 controlled by the master driver IC 70 or a second portion 73 of the pixel array 34 controlled by a slave driver IC 72 and, in response to a determination that the image data is addressed to the second portion 73 of the pixel array 34, transmit the image data to the slave driver IC 72. Likewise, the master driver (e.g., IC 70) may determine whether image data is addressed to a first portion 71 of the pixel array 34 controlled by the master driver IC 70 or a third portion 75 of the pixel array 34 controlled by a slave driver IC 74 and, in response to a determination that the image data is addressed to the third portion 75 of the pixel array 34, transmit the image data to the slave driver IC 74. Other embodiments may include additional driver ICs, e.g., more than three, more than four, more than six, or more than eight. The driver ICs 70, 72, and 74 may be closer to the pixels that they control relative to embodiments with fewer driver ICs, and this shorter distance may reduce signal attenuation. Further, any space between the driver ICs 70, 72, and 74 may be advantageously utilized for additional components or features.

FIG. 5 is a schematic representation of the LCD 12 illustrating additional details. In addition to the previously described components 14, 16, 34, 40, and 44, the LCD 12 may include a backlight 82 and memory 84 and 86 in the driver ICs 14 and 16.

The LCD 12 may include a plurality of devices that are formed on the substrate 32 (FIG. 2), e.g., a glass substrate, including pixel array 34. The illustrated pixel array 34 may include a plurality of sub-pixels 88, and a plurality of gate-line transistors 89, all formed on the substrate 32 (FIG. 2). The illustrated sub-pixels 88 may be generally arranged in rows and columns with each sub-pixel 88 in a row coupled to a source line 90 and each sub-pixel 88 in a column coupled to a gate line 92. The illustrated sub-pixels 88 are generally

arranged in a rectangular lattice, but in other embodiments they may be arranged differently, e.g., in a hexagonal lattice.

Each of the illustrated sub-pixels 88 may include an access transistor 94, a light switch 96, and a capacitor 98. The access transistors 94 may be formed on the substrate 32 (FIG. 2) by depositing a semiconductor, such as amorphous silicon or polycrystalline silicon, on the substrate 32 (FIG. 2) and patterning the semiconductive material with lithography, e.g., photolithography. The semiconductive material may be selectively doped to form a source, a drain, and a channel in each of the access transistors 94, and an insulator, such as silicon dioxide, and a conductive material may be patterned on the substrate 32 (FIG. 2) to form a gate adjacent the channel in each of the access transistors 94. The light switch 96 may include a liquid crystal disposed between two conductive transparent or translucent electrodes and two generally orthogonally-oriented light-polarizing layers. Biasing the electrodes may orient the liquid crystal such that light may be selectively transmitted through the light-polarizing layer 28 (FIG. 2) according to the electrical state of the electrodes. The color filter 30 (FIG. 2) may include colored translucent regions disposed across each sub-pixel 88 to selectively transmit a particular frequency of light, e.g., red, blue, or green, such that applying a voltage to the sub-pixel 88 renders the sub-pixels 88 generally transparent or translucent to certain frequencies of light. The capacitor 98 may include a plate coupled to one of the electrodes in the sub-pixel 88 and another plate coupled to a common voltage source, e.g., ground, or an adjacent gate line 92. The capacitor 98 may generally maintain a voltage across the electrodes in the sub-pixel 88 when the sub-pixel 88 is not being addressed.

The gates of each of the access transistors 94 may be connected to one of the gate lines 92, which may be generally integrally formed with the gate of the access transistors 94, or it may be formed in a different step. The illustrated gate lines 92 couple to a plurality of sub-pixels 88 disposed in a given column. In some embodiments, the gate lines 92 are coupled at one end to a load circuit that tends to render the access transistors 94 conductive and at the other end to a pull-down voltage source 100 that tends to render the access transistors 94 nonconductive. The source and drain of the illustrated gate-line transistors 89 may be coupled in series between the pull-down voltage source 100 and the gate lines 92, such that the gate-line transistors 89 control whether the access transistors 94 on a given gate line 92 are conductive or nonconductive. A gate of each of the gate-line transistors 89 may be coupled to one of the driver ICs 14 or 16.

The sources of the access transistors 94 on a given row may be connected to a source line 90, which like the other features on the substrate 16, may be formed by deposition, lithography, and etching. The source lines 90 may connect to the driver IC 14 through a source-line bus 102. Image data, such as the degree to which a given light switch 96 in a given sub-pixel 88 should transmit light, may be transmitted from the driver IC 14 to the sub-pixels 88 via the source-line bus 102 and the appropriate source line 90. The image data may be in the form of a voltage that when formed across the electrodes in one of the light switches 96, allows the appropriate amount of light through the light switch 96.

The backlight 82 may be configured to supply light to one side of the sub-pixels 88. In some embodiments, the backlight 82 includes one or more fluorescent lights or one or more light-emitting diodes, e.g. white-light emitting diodes. A light-guide and a reflective layer may distribute light from the backlight 82 generally evenly among the sub-pixels 88, which may selectively transmit this light. In some embodiments, the sub-pixels 88 are transreflective sub-pixels that have a reflective

portion that selectively reflects ambient light and a transmissive portion that selectively transmits light from the backlight 82.

The driver ICs 14 and 16 may each include memory 84 or 86. The memory 84 and 86 may be non-volatile in order to store configuration settings for the LCD 12. For example, the memory 84 and 86 may store gamma levels or other image parameters and panel calibrations. The configuration settings in the memory 84 and the memory 86 may be used to tune the driver ICs 14 and 16 so that the sub-pixels 88 that they control output generally similar light intensities in response to generally similar image data. Values in the memory 84 and 86 may be used to match the performance of the driver ICs 14 and 16.

As illustrated by FIG. 5, the driver IC 14 communicates with the driver IC 16 through the inter-driver bus traces 40. To transmit signals on these traces 40, the driver IC 14 may include an output referred to as a "cascade output" that couples to the inter-driver bus traces 40, and the driver IC 16 may include an input referred to as a "cascade input" that couples to the other end of the inter-driver bus traces 40. In some embodiments, the driver ICs 14 and 16 may be generally similar or identical and may both have a cascade input on one side and a cascade output on the other side. The cascade input may remain unused on the master driver IC 14 and the cascade output may remain unused on the slave driver IC 16.

In operation, the driver ICs 14 and 16 receive image data and, based on this data, output signals that adjust the sub-pixels 88. The image data may be received from other components of an electronic device including the LCD 12. The image data may indicate which sub-pixels 88 should be rendered transmissive and the degree to which they should be rendered transmissive to form an image conveyed by the image data, such as a frame in a video. The image data and power may be delivered through the flex cable 44 to the master driver IC 14. The master driver IC 14 may then determine whether the image data addresses one of the sub-pixels 88 coupled to the master driver IC 14 or one of the sub-pixels 88 coupled to the slave driver IC 16. The data directed to the slave driver IC 16 may be routed along with electrical power through the inter-driver bus traces 40 to the slave driver IC 16. Prior to transmitting the image data to the appropriate sub-pixels 88, the driver ICs 14 and 16 may process the image data based on configuration values stored in the memory 84 or 86, e.g., by changing the gamma values of the image data to reduce artifacts from having separate driver ICs 14 and 16.

To display the image, the driver ICs 14 and 16 may generally individually access each column of sub-pixels 88 to which they are coupled and adjust the voltage across the electrodes in each of the light switches 96 in those sub-pixels 88. To access a column of sub-pixels 88, in this embodiment, the driver ICs 14 and 16 may turn off the gate-line transistor 89 associated with the column of sub-pixels 88 being addressed. Turning off the gate-line transistor 89 may impede or prevent the pull-down voltage source 100 from holding down the voltage of the gate line 92, and the voltage of the addressed gate line 92 may rise in response to the gate-line transistor 89 being turned off, as current flowing between the gate line 92 and a load circuit may increase the voltage of the gate line 92. This change in voltage may render the access transistors 94 on the addressed column conductive. Image data appropriate for the addressed column may be transmitted from the driver IC 14 to each of the source lines 90. The voltages of the source lines 90 may drive current between the source lines 90 and both the capacitor 98 and the electrodes in the light switches 96, thereby updating the light-conductive state of the light switches 96 according to the image data.

After the sub-pixels 88 in a column are adjusted, the gate-line transistor 89 for that column may turn back on, and the pull-down voltage source 100 may lower the voltage of the gate line 92 and turn off the access transistors 94 on that column, thereby impeding the sub-pixels 88 from changing until the next time that they are addressed. The driver ICs 14 and 16 may repeat this process for each of the gate lines 92 to produce an image. In some embodiments, groups of sub-pixels 88 each having a filter of a different color may together form a single pixel of the resulting image.

FIG. 6 illustrates an example of an electronic device 104 that may include the LCD 12 of FIG. 2 or the LCD 68 of FIG. 4, or variations thereof. The electronic device 104 may also include a user interface 106, a power source 108, input/output ports 110, memory 112, a processor 114, storage 116, an expansion card 118, and a network device 120.

The user interface 106 may include one of the user interfaces described above, such as a layer responsive to a contact from, or close proximity of, a finger or a stylus, such as a digitizer. In some embodiments, this layer may be responsive to multiple areas of contact, e.g., a multi-touch digitizer. Or, the user interface 106 may include a keypad (e.g. a slide-out keypad or a keyboard), a microphone, a camera, a stylus, or an accelerometer.

The power source 108 may include a portable power source, such as a lithium-ion battery, a nickel-metal-hydrate battery, or a fuel cell. In some embodiments, the power source 108 may include a transformer configured to condition grid power for use by the electronic device 104.

The input/output ports 110 may include ports compliant with a variety of different communications standards. For example, the input/output ports 110 may include a universal serial bus (USB) port, a FireWire port, a serial port, a parallel port, a headphone port, a microphone port, a video graphics array port, a digital visual interface port, or various other ports.

The memory 112 may include solid state memory, such as a solid-state drive or ROM memory, or a disc drive. The memory 112 may store software for execution on the processor 114. For example, the memory 112 may store a basic input/output system (BIOS), an operating system and various applications, such as an office productivity suite, a browser, a media player, or an e-mail application. This software may be stored on a machine readable medium, such as one of those mentioned above.

The processor 114 may be configured to control the operation of the electronic device 104 by interfacing with each of its components 106, 12, 108, 110, 112, 116, 118, and 120. The processor 114 may be configured to execute the software stored in the memory 112 and coordinate movement of data through the electronic device 104.

The storage 116 may include volatile memory, such as dynamic random access memory (DRAM) or static random access memory (SRAM), or nonvolatile memory, such as NAND or NOR flash memory. In some embodiments, the storage 116 may include space on a hard drive or a solid-state drive or an optical media. In some embodiments, the storage 116 may include machine readable media storing music or video data, such as music or video data encoded in Advanced Audio Coding (AAC) or other compression format, such as MP3, MP4, OGG, WAV, FLAC, or Apple Lossless format.

The expansion card 118 may include a variety of types of expansion cards or slots for expansion cards. For example, the expansion card 118 may include memory or a slot for memory, such as solid state memory card. In some embodi-

ments, the expansion card **118** may include a card or a slot for a card that adds functionality, such as a GPS unit, a cable card, or a data acquisition card.

The network device **120** may be a wired or wireless network device configured to transmit and receive data over a network, such as the Internet, a local area network, a wireless area network, a personal area network, or a sensor area network. In some embodiments, the network device **120** includes a wireless network device, such as a Bluetooth transceiver, a WiFi transceiver, a cellular data or voice signal transceiver, or an infrared transceiver. In some embodiments, the network device **120** includes a wired network device, such as an Ethernet card or modem.

Other embodiments may include other types of electronic devices **104**. In some embodiments, the electronic device **104** may include a GPS module, and the memory **112** may store maps for displaying GPS position data on the LCD **12**. The electronic device **104** may also be one of a variety of types of displays, such as a television, a dynamically updated photo frame, a monitor of a laptop, palmtop, or desktop computer, or one of a variety of types of equipment, such as an automated teller machine, a point-of-sale terminal, a medical device, or a manufacturing device. In some embodiments, the electronic device **104** is a hand-held gaming device, and the memory **112** stores one or more video games. The electronic device may also be a display module in a vehicle that displays information about the state of the vehicle, e.g., position, velocity, or an image from a vehicle-mounted camera.

ELEMENT-NUMBER LIST

10 electronic device
12 LCD
14 two driver ICs
16 two driver ICs
18 longitudinal central axis
20 area
22 body
24 power button
26 speaker
28 polarizer
30 color filter
32 substrate
34 pixel array
36 fanout traces
38 fanout traces
40 inter-driver bus traces
42 input traces
44 flex cable
46 thickness
48 thickness
50 thickness
52 width
54 height
56 top edge
58 distance
60 width
62 top edge
64 distance
66 thickness
68 LCD
70 three driver ICs
72 three driver ICs
74 three driver ICs
76 first portion
78 inter-driver bus
80 second portion

82 backlight
84 memory
86 memory
88 sub-pixels
89 gate-line transistors
90 source line
92 gate line
94 access transistor
96 light switch
98 capacitor
100 pull-down voltage source
102 source-line bus
104 electronic device
106 user interface
108 power source
110 input/output ports
112 memory
114 processor
116 storage
118 expansion card
120 network device

What is claimed is:

1. A method, comprising:

receiving image data in a master driver IC;

determining via the master driver IC whether the image data is addressed to a first portion of a pixel array controlled by the master driver IC or a second portion of the pixel array controlled by a slave driver IC; and

in response to a determination that the image data is addressed to the second portion of the pixel array, transmitting the image data to the slave driver IC from the master driver IC.

2. The method of claim 1, wherein receiving image data in a master driver IC comprises receiving image data via a flexible cable coupled to the master driver IC.

3. The method of claim 1, comprising:

determining via the master IC whether the image data is addressed to a third portion of the pixel array controlled by another slave driver IC; and

in response to a determination that the image data is addressed to the third portion of the pixel array, transmitting the image data to the other slave driver IC from the master driver IC.

4. The method of claim 1, comprising changing a transmissive state of a sub-pixel on an amorphous silicon LCD based on the image data.

5. The method of claim 1, comprising forming the image data based on data received over a cellular network.

6. The method of claim 1, comprising forming the image data based on data received from a server over the Internet.

7. A system, comprising:

a hand-held electronic device comprising:

a multi-touch touch screen sensor;

a display disposed adjacent the multi-touch touchscreen sensor, wherein the display comprises a plurality of driver ICs, wherein the plurality of driver ICs comprise a first driver IC and a second IC, wherein the first driver IC is configured to receive image data and determine whether the image data is addressed to a first portion of a pixel array controlled by the first driver IC or a second portion of the pixel array controlled by the second driver IC and transmit the image data to the second driver IC from the first driver IC when the first driver IC determines that the image data is addressed to the second portion of the pixel array.

8. The system of claim 7, wherein the display comprises an amorphous silicon LCD.

11

9. The system of claim 7, wherein each of the plurality of driver ICs are disposed on different sides of a central longitudinal axis of the display.

10. The system of claim 7, wherein the first driver IC comprises a master driver IC and the second driver IC comprises a slave driver IC. 5

11. The system of claim 10, wherein the master driver IC is spaced away from the slave driver IC by a distance between about 10 mm and about 20 mm.

12. The system of claim 7, comprising a flex cable coupled to the first driver IC and configured to transmit the image data to the first driver IC. 10

13. The system of claim 7, wherein the plurality of driver ICs comprise a third driver IC, wherein the first driver IC is configured to determine whether the image data is addressed to a third portion of the pixel array controlled by the third driver IC and transmit the image data from the first driver IC to the third driver IC when the first driver IC determines that the image data is addressed to the third portion of the pixel array. 15

14. The system of claim 13, wherein the third driver IC comprises a second slave driver. 20

15. A device comprising, comprising:

a master driver IC configured to receiving image data and control a first portion of a pixel array; and 25

a slave driver IC configured to control a second portion of the pixel array, wherein the master driver IC is config-

12

ured to determine whether the image data is addressed to the first portion of the pixel array or the second portion of the pixel array, wherein the master driver IC is configured to transmit the image data to the slave driver IC in response to a determination that the image data is addressed to the second portion of the pixel array.

16. The device of claim 15, comprising a flex cable coupled to the master driver IC and configured to transmit the image data to the master driver IC.

17. The device of claim 15, comprising:

a second slave driver IC configured to control a third portion of the pixel array, wherein the master driver IC is configured to transmit the image data to the second slave driver IC in response to a determination that the image data is addressed to the second portion of the pixel array.

18. The device of claim 15, comprising an amorphous silicon LCD comprising a sub-pixel, wherein a transmissive state of the sub-pixel is configured to be changed based on the image data.

19. The device of claim 15, comprising a processor configured to form the image data based on data received over a cellular network.

20. The device of claim 15, comprising a processor configured to form the image data based on data received from a server over the Internet.

* * * * *

专利名称(译)	显示器具有多个驱动器集成电路		
公开(公告)号	US8743335	公开(公告)日	2014-06-03
申请号	US13/620014	申请日	2012-09-14
[标]申请(专利权)人(译)	苹果公司		
申请(专利权)人(译)	苹果公司.		
当前申请(专利权)人(译)	苹果公司.		
[标]发明人	GETTEMY SHAWN R VIERI CARLIN J LEE YONGMAN YAO WEI H		
发明人	GETTEMY, SHAWN R. VIERI, CARLIN J. LEE, YONGMAN YAO, WEI H.		
IPC分类号	G02F1/1345		
CPC分类号	G09G3/3666 G09G2300/0417 G02F1/136277 G09G2320/0223 G02F1/13452 G09G2300/0426 G02F2202/103		
审查员(译)	NGUYEN, 龚便		
其他公开文献	US20130009899A1		
外部链接	Espacenet USPTO		

摘要(译)

公开了一种电子设备。在一些实施例中，电子设备包括液晶显示器（LCD）和耦合到LCD的多个驱动器集成电路（IC）。驱动器IC可以沿着LCD的一侧布置在非中心位置附近，并且在一些实施例中，驱动器IC中的一个可以是主驱动器IC，而其他驱动器IC或驱动器IC可以从驱动器IC。

