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Baer

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(54) **CMOS STEREO IMAGING SYSTEM AND METHOD**

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(51) **Int. Cl.**

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G06K 9/00	(2006.01)
H04N 15/00	(2006.01)

(52) **U.S. Cl.** **250/208.1**; 396/324; 348/42; 352/57

(58) **Field of Classification Search** 250/208.1; 348/42, 43, 46, 47, 48; 356/611, 12; 382/154; 352/57; 396/324; 378/41; 355/22
See application file for complete search history.

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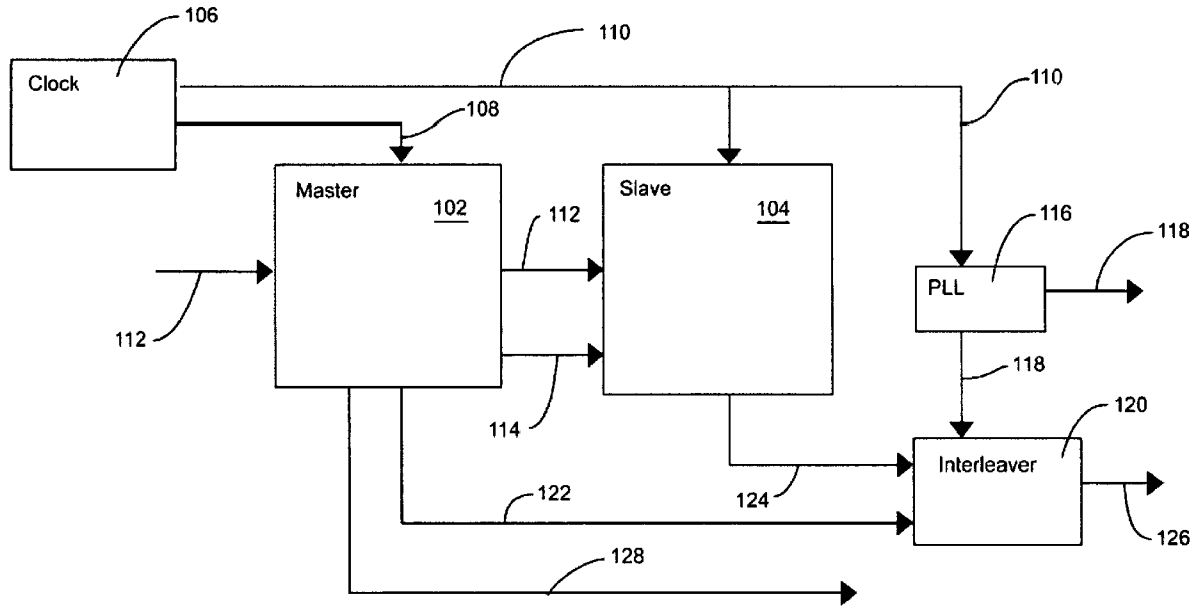
(57) **ABSTRACT**

A pair of CMOS image sensors is provided. One of the pair of CMOS image sensors is assigned as a master CMOS image sensor and the other is assigned as a slave CMOS image sensor. The slave CMOS image sensor is synchronized to the master CMOS image sensor during image data acquisition. In one embodiment, the master CMOS image sensor and the slave CMOS image sensor are connected to receive a control signal, which assigns the master CMOS image sensor as master and the slave CMOS image sensor as slave. In another embodiment, the master CMOS image sensor and slave CMOS image sensor are hardwired to assign the master and slave. In yet another embodiment, the data signals from the master CMOS image sensor and slave CMOS image sensor are interleaved.

20 Claims, 3 Drawing Sheets



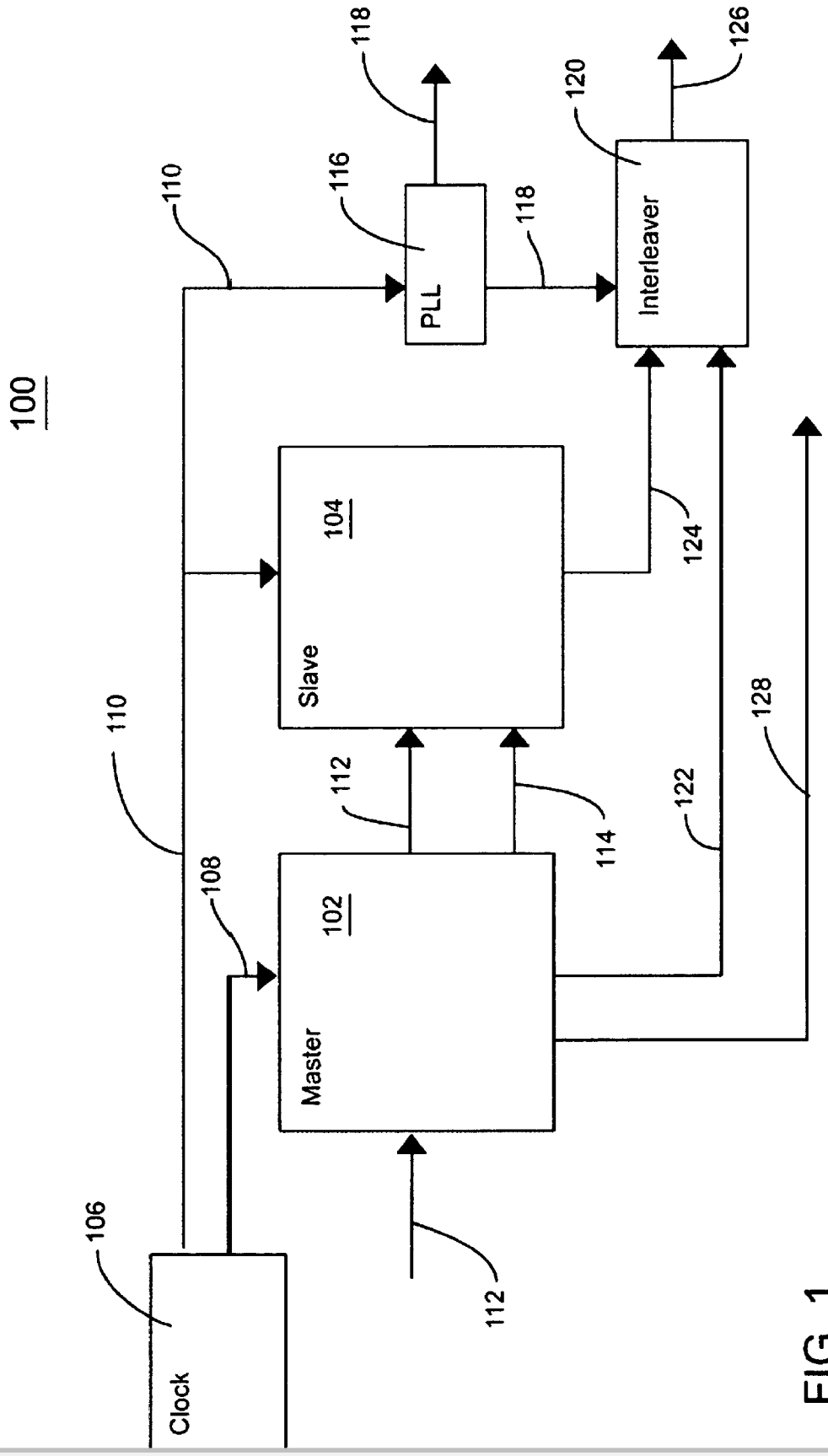


FIG. 1

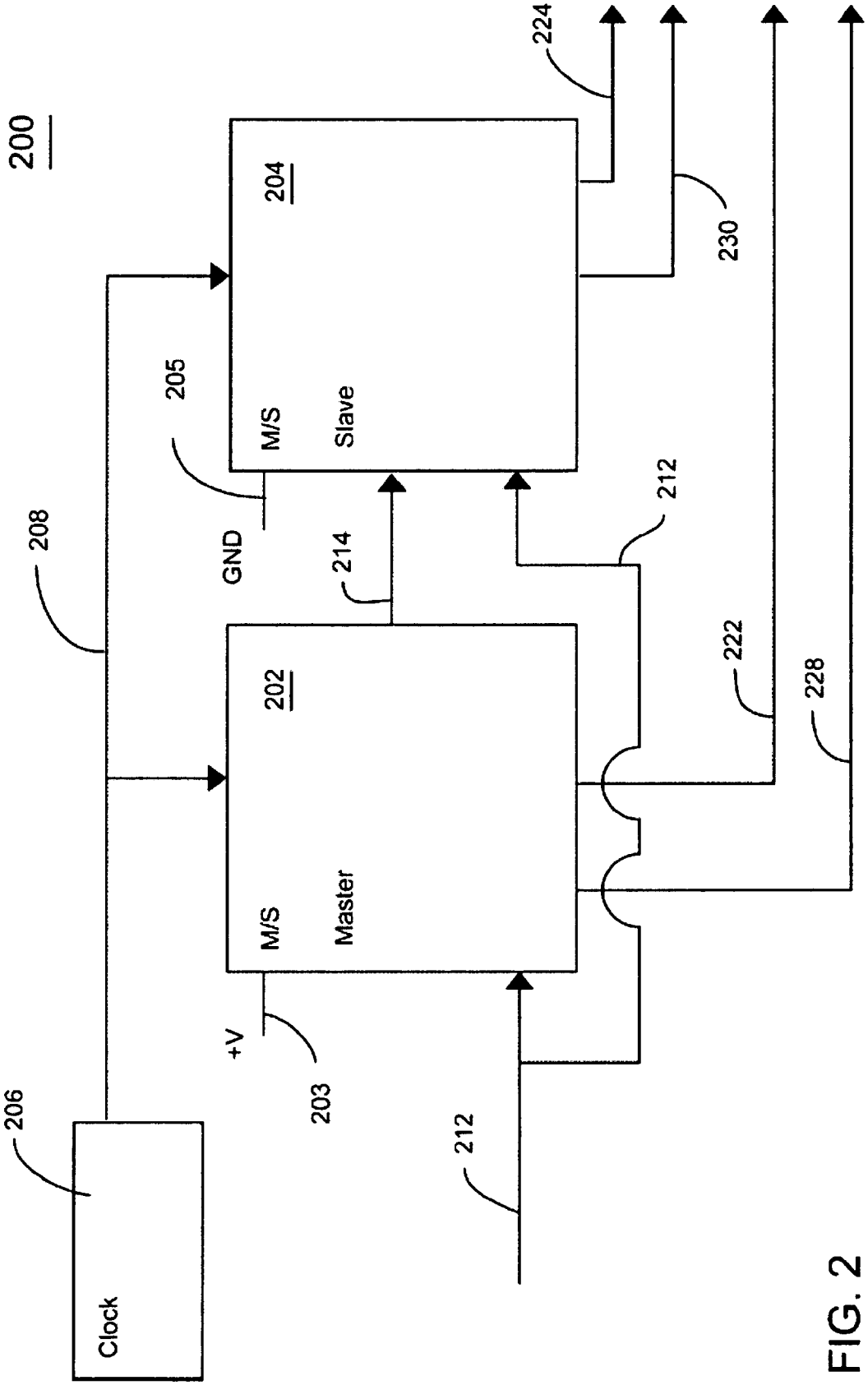


FIG. 2

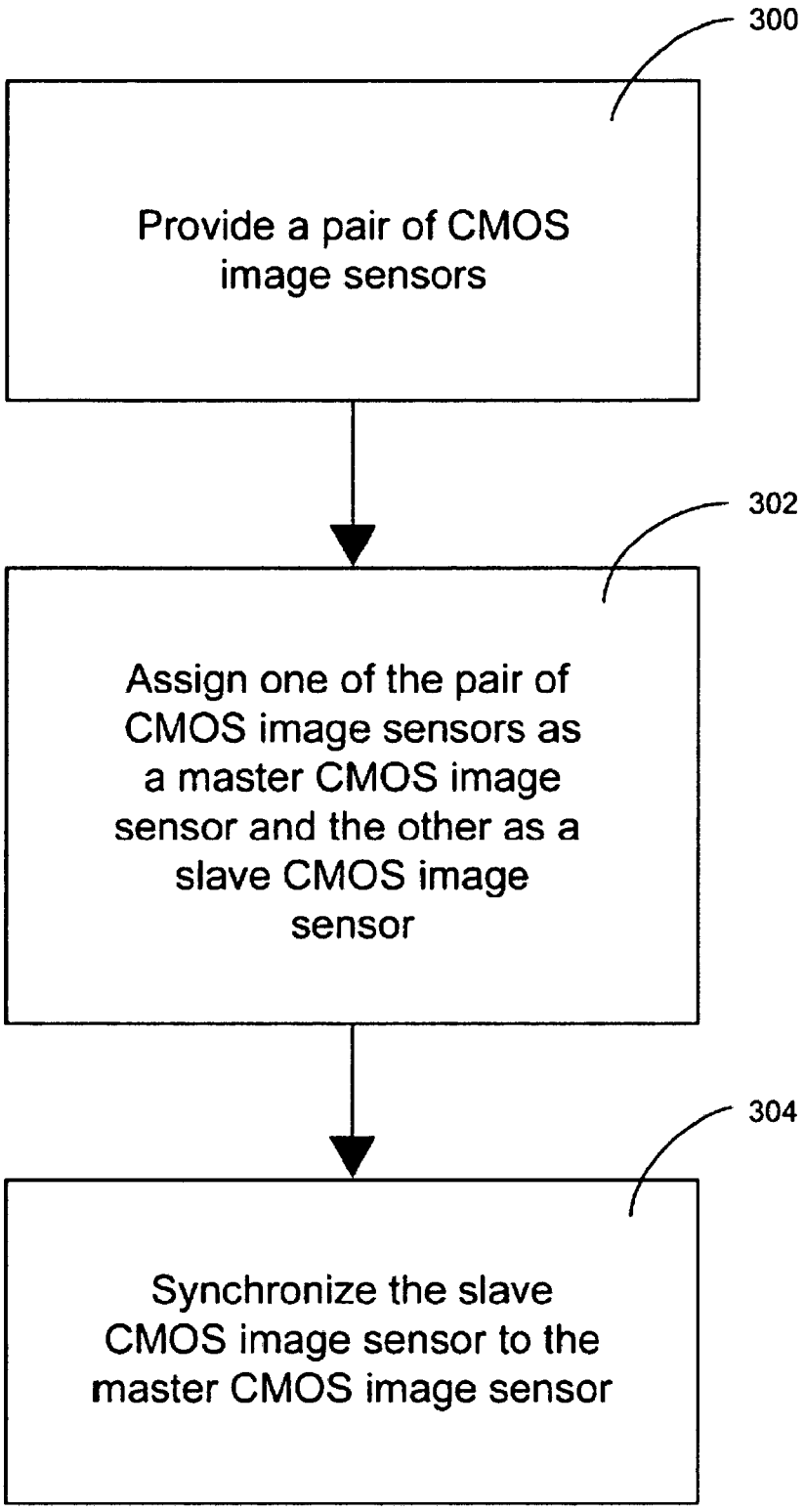


FIG. 3

CMOS STEREO IMAGING SYSTEM AND METHOD

TECHNICAL FIELD

The technical field of this disclosure is digital imaging circuits, particularly digital imaging circuits using complementary metal oxide semiconductor (CMOS) imaging sensors to capture stereo pairs and methods of using the same.

BACKGROUND OF THE INVENTION

Stereo imaging uses planar imagers to acquire three-dimensional information about a scene. To obtain the third dimension of depth, two planar imagers are offset by a distance to determine the relative position of objects in the scene. Two types of stereo cameras using conventional cameras with photochemical film as the imager are available. In one, a special offset optics system is used to create two images on a single frame of film by opening a single shutter. In the other, two independent offset cameras with coordinated shutters are used to simultaneously expose two frames of film. Conventional cameras present certain problems as stereo cameras, however. They are complicated, expensive mechanical devices and photochemical film requires the images to be developed and converted to digital data.

The development of charge-coupled device (CCD) image sensors has led to their use in stereo cameras. A CCD image sensor comprises a two-dimensional array of photodiodes which convert received light into a charge. For stereo imaging, two CCD image sensors offset by a distance collect two images using global electronic shutters to synchronize the images. The electronic image data is then read out sequentially. CCD image sensors are expensive in themselves and less than ideal for this application. CCD image sensors require substantial off-chip support circuitry, such as power supplies, device drivers, timing generation, and analog to digital conversion. In addition, CCD image sensors use large amounts of power, requiring large battery capacity in battery-powered devices. This makes CCD-based stereo cameras complicated and expensive.

It would be desirable to have a stereo imaging system and method of using the same that would overcome the above disadvantages.

SUMMARY OF THE INVENTION

The present invention uses low-power CMOS image sensors for stereo imaging. A master CMOS image sensor receives the instruction to acquire an image and synchronizes the operation of a slave CMOS image sensor, so that the master and slave CMOS image sensors acquire their images simultaneously. The master and slave CMOS image sensors are separated by an offset distance so the data from the two-dimensional images can be combined into three-dimensional data.

One aspect of the present invention provides a method for stereo imaging using CMOS image sensors. A pair of CMOS image sensors is provided. One of the pair of CMOS image sensors is assigned as master CMOS image sensor and the other is assigned as slave CMOS image sensor. The slave CMOS image sensor is synchronized to the master CMOS image sensor during image data acquisition.

Another aspect of the present invention provides a system

receive a control signal, the master CMOS image sensor generating a timing signal; and a slave CMOS image sensor connected to receive the control signal and the timing signal. The timing signal synchronizes the slave CMOS image sensor to the master CMOS image sensor during image data acquisition.

The foregoing and other features and advantages of the invention will become further apparent from the following detailed description of the presently preferred embodiments, read in conjunction with the accompanying drawings. The detailed description and drawings are merely illustrative of the invention, rather than limiting, the scope of the invention being defined by the appended claims and equivalents thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1**–**2** show block diagrams for stereo imaging systems using CMOS image sensors according to the present invention; and

FIG. **3** shows a flow chart of a method for stereo imaging using CMOS image sensors according to the present invention.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

The invention is based on the observation that the above-described problems arise from difficulties in using CCD image sensors in stereo imaging systems. CCD image sensors require substantial off-chip support circuitry and use large amounts of power, making CCD-based stereo cameras complicated and expensive. CCD image sensors have one advantage for stereo imaging, however. CCD image sensors collect an image over the whole image frame at once using a global shutter, also known as a frame shutter. To synchronize a pair of CCD image sensors in a stereo imaging system, the pair of CCD image sensors only needs to start acquiring data at the same time and have the same exposure settings. Unlike CCD image sensors, CMOS image sensors collect an image a line at a time using a rolling shutter. If one CMOS image sensor in a stereo imaging system is rolling at the top of its frame and the other CMOS image sensor is rolling in the middle of its frame, corresponding lines in the images will be acquired at different times. In accordance with the invention, the rolling shutters of the pair of CMOS image sensors in a stereo imaging system are synchronized to acquire corresponding lines of the images at the same time. This way, movement in the image is not confused with depth information.

FIGS. **1**–**2** show block diagrams for stereo imaging systems using CMOS image sensors. Generally, a pair of complementary metal oxide semiconductor (CMOS) imaging sensors is provided. The CMOS image sensors are offset from one another at a distance parallel to the plane in which the CMOS image sensors are arranged. One CMOS image sensor is designated as master and the other is designated as slave. The master CMOS image sensor receives the instruction to acquire an image and synchronizes the operation of the slave CMOS image sensor, so that the master and slave CMOS image sensors acquire their images simultaneously. The CMOS image sensors are synchronized and the image acquisition is simultaneous so that three-dimensional images are obtained without error due to motion of the subjects in the image. The offset distance between the image sensors

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