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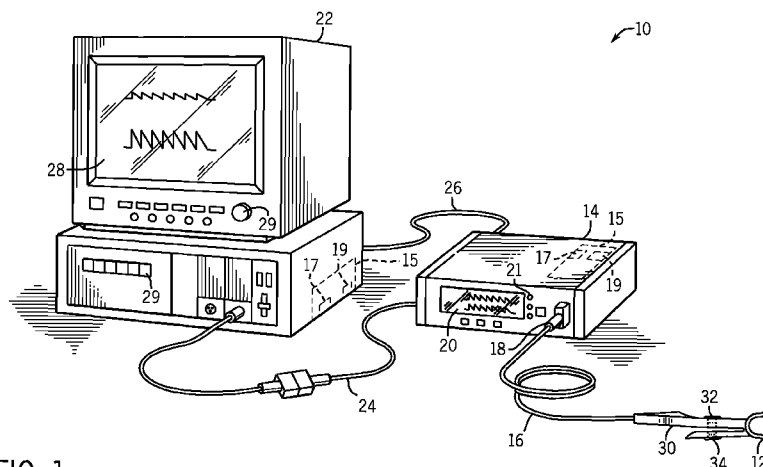


FIG. 1

(57) Abstract: An evaluation board for a medical monitoring module is provided. The evaluation board includes a socket configured to receive a medical monitoring module and a plurality of connections for connection to a host or host simulator and a second device. The evaluation board may include a non-isolated power supply to provide power to the medical monitoring module. The evaluation board may also provide communication in a protocol between the host or host simulator and the medical monitoring module.

EVALUATION BOARD FOR A MEDICAL MONITORING MODULE SYSTEM AND METHOD

BACKGROUND

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The present disclosure relates generally to medical monitoring systems, and more particularly, to testing and integration of medical monitoring modules with medical monitors.

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This section is intended to introduce the reader to various aspects of art that may be related to various aspects of the present disclosure, 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 disclosure. Accordingly, it should be understood that these statements are to be read in this light, and not as admissions of prior art.

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In the field of medicine, doctors often desire to monitor certain physiological parameters of their patients. A medical monitoring system may include a monitor that receives signals from various types of optical, electrical, and acoustic sensors. These monitors may display various physiological parameters to a caregiver via a display. In some instances, the sensors and any corresponding hardware may be manufactured by a single manufacturer and may communicate over a proprietary protocol. Additionally, designing a medical monitor that is operative with such sensors, corresponding hardware, and protocols may be challenging. The medical monitor may not provide the signal processing, power, or other features expected by the sensor and corresponding hardware. Additionally, monitoring and testing of the various devices may not be easily performed.

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BRIEF DESCRIPTION OF THE DRAWINGS

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

Fig. 1 depicts a medical monitoring system in accordance with an embodiment of the present disclosure;

Fig. 2 is a schematic of an evaluation board for a monitoring, testing and debugging system in accordance with an embodiment of the present disclosure;

Fig. 3 is a schematic of a first configuration of a monitoring, testing, and debugging system having the evaluation board of Fig. 2 and a medical monitoring module in accordance with an embodiment of the present disclosure;

Fig. 4 is a schematic of a second configuration of a monitoring, testing, and debugging system having the evaluation board of Fig. 2 and a medical monitoring module in accordance with an embodiment of the present disclosure;

Fig. 5 is a schematic of a third configuration of a monitoring, testing, and debugging system having the evaluation board of Fig. 2 and a medical monitoring module in accordance with an embodiment of the present disclosure;

Fig. 6 is a flowchart of a process for use and operation of the evaluation board of Fig. 2 in accordance with an embodiment of the present disclosure;

Fig. 7 is a flowchart depicting operation of a protocol analyzer 70 in accordance with an embodiment of the present disclosure;

Figs. 8-12 are screenshots of a protocol analyzer 70 in accordance with an embodiment of the present disclosure;

Fig. 13 is a flowchart depicting operation of a host simulator 72 in accordance with an embodiment of the present disclosure; and

Fig. 14 is a screenshot of a host simulator 72 in accordance with an embodiment of the present disclosure.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

One or more specific embodiments of the present techniques 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 depicts a medical monitoring system **10** having a sensor **12** coupled to a monitor **14** in accordance with an embodiment of the present disclosure. The sensor **12** may be coupled to the monitor **14** via sensor cable **16** and sensor connector **18**, or the sensor **12** may be coupled to a transmission device (not shown) to facilitate wireless transmission between the sensor **12** and the monitor **14**. The monitor **14** may be any suitable monitor, such as those available from Nellcor Puritan Bennett, LLC. The monitor **14** may be configured to calculate physiological parameters from signals received from the sensor **12** when the sensor **12** is placed on a patient. In some embodiments, the monitor **14** may be primarily configured to determine, for example blood and/or tissue oxygenation and perfusion, respiratory rate, respiratory effort, continuous non-invasive blood pressure, cardiovascular effort, glucose levels, level of consciousness, total hematocrit, hydration, electrocardiography, temperature, or any other suitable physiological parameter. To enable this functionality, the monitor **14** may include a medical monitoring module **15** that communicates with the sensor **12** and outputs information based on data received from the sensor **12**. The module **15** may be a printed circuit board assembly having one or processors **17** and/or memory **19**. The memory **19** may include volatile memory (e.g., RAM) and non-volatile memory (e.g., ROM, flash memory, etc.) For example, in one embodiment, the monitor **14** may be a pulse oximetry monitor and the module **15** may be a pulse oximetry module that is/may be configured to provide oxygen saturation (SpO₂), pulse rate, pulse waveform and pulse

amplitude modulation (also referred to as “Blip”), interference indicators, sensor disconnect indicators, sensor off patient indicators, sensor adjust messages, alarm management, and/or analog outputs. In such an embodiment, the monitor **14** may be a monitor manufactured by Nellcor Puritan Bennett, LLC, and the medical monitoring module **15** may be a NELL-1, NELL-2, or NELL-3 pulse oximetry module available from Nellcor Puritan Bennett, LLC. Additionally, the monitor **14** may include a display **20** configured to display information regarding the physiological parameters, information about the system, and/or alarm indications. The monitor **14** may include various input components **21**, such as knobs, switches, keys and keypads, buttons, etc., to provide for operation and configuration of the monitor.

Furthermore, to upgrade conventional operation provided by the monitor **14** to provide additional functions, the monitor **14** may be coupled to a multi-parameter patient monitor **22** via a cable **24** connected to a sensor input port or via a cable **26** connected to a digital communication port. In addition to the monitor **14**, or alternatively, the multi-parameter patient monitor **22** may be configured to calculate physiological parameters and to provide a central display **28** for information from the monitor **14** and from other medical monitoring devices or systems. In some embodiments, the monitor **22** may be primarily configured to display and/or determine, for example blood and/or tissue oxygenation and perfusion, respiratory rate, respiratory effort, continuous non-invasive blood pressure, cardiovascular effort, glucose levels, level of consciousness, total hematocrit, hydration, electrocardiography, temperature, or any other suitable physiological parameter. To enable this functionality, the monitor **22** may additionally, or alternatively, include the medical monitoring module **15** that communicates with the sensor **12** (and/or monitor **14**) and outputs information based on data received from the sensor **12** (and/or monitor **14**). The monitor **22** may include a slot, socket, or other receptacle configured to receive the medical monitoring module **15**. In other embodiments, the medical monitoring module **15** or the components thereof may be physically and electronically integrated with a circuit board or other electronic component of the monitor **22**. In one embodiment, the module **15** may be a pulse oximetry module that may be configured to provide oxygen saturation (SpO₂), pulse rate, pulse waveform and pulse amplitude modulation (also referred to as “Blip”),

interference indicators, sensor disconnect indicators, sensor off patient indicators, sensor adjust messages, alarm management, and/or analog outputs to the monitor **22**. For example, the multi-parameter patient monitor **22** may be configured to display an SpO₂ signal (such as a plethysmographic waveform) on the display **28**. In such an embodiment, the medical monitoring module **15** may be a NELL-1, NELL-2, or NELL-3 pulse oximetry module available from Nellcor Puritan Bennett, LLC. The monitor may include various input components **29**, such as knobs, switches, keys and keypads, buttons, etc., to provide for operation and configuration of the monitor **22**. In addition, the monitor **14** and/or the multi-parameter patient monitor **22** may be connected to a network to enable the sharing of information with servers or other workstations.

In some embodiments, the multi-parameter patient monitor **22** having the medical monitoring module **15** may be directly connected to the sensor **12**. In such an embodiment, the system **10** may not include the monitor **14** and may rely on direct communication between the multi-parameter patient module **22** and the module **15**. As discussed further below, monitoring, testing, and debugging of the module **15** (and communication to and from the module **15**), either as a standalone module or when installed or integrated into the monitor **22**, may be performed using the system and techniques described herein.

The sensor **12** may be any sensor suitable for detection of any physiological parameter. The sensor **12** may include optical components (e.g., one or more emitters and detectors), acoustic transducers or microphones, electrodes for measuring electrical activity or potentials (such as for electrocardiography), pressure sensors, motion sensors, temperature sensors, etc. In one embodiment, the sensor **12** may be configured for photo-electric detection of blood and tissue constituents. For example, the sensor **12** may be a pulse oximetry sensor such as those available from Nellcor-Puritan Bennett. As shown in **Fig. 1**, the sensor **12** may be a clip-type sensor suitable for placement on an appendage of a patient, e.g., a digit, an ear, etc. In other embodiments may be a bandage-type sensor having a generally flexible sensor body to enable conformable application of the sensor **12** to a sensor site on a patient. In yet other embodiments, the sensor **12** may be secured to a patient via adhesive (e.g., in an embodiment having an electrode sensor) on the underside of the sensor body or by an external device such as headband or other

elastic tension device. In yet other embodiments, the sensor **12** may be configurable sensors capable of being configured or modified for placement at different sites (e.g., multiple tissue sites such as a digit, a patient's forehead, etc.).

5 In one embodiment, the sensor **12** may include a sensor body **30** having an emitter **32** for emitting light at certain wavelengths into a patient's tissue and a detector **34** for detecting the light after it is reflected and/or absorbed by the patient's blood and/or tissue. In such an embodiment where the sensor **12** is a pulse oximetry sensor or other photo-electric sensor, the emitter **32** may be configured to emit one or more wavelengths
10 of light, e.g., red and infrared (IR), such as through LED's or other light sources. The detector **34** may include photo-detectors for detecting the wavelengths of light reflected or transmitted through blood or tissue constituents of a patient and converting the intensity of the received light into an electrical signal.

 The module **15** may communicate with the sensor **12** over a proprietary interface
15 and/or protocol. Additionally, the monitor **14** (and monitor **22**) may communicate with the module **15** over an identical or different proprietary protocol, such that messages sent between the module **15** and other devices may be formatted according to a proprietary protocol. To enable this functionality, the module **15** may include hardware and software components to implement the proprietary interfaces and/or protocols. In one
20 embodiment, the protocol implemented by the module **15** may be the Standard Host Interface Protocol (SHIP) developed by Nellcor Puritan Bennett, LLC. In such embodiments, design, debug, and testing of a monitor to ensure operability with the sensor **12** and/or the corresponding module **15** may be difficult. Additionally, monitoring, testing, and debugging interaction of devices with the proprietary protocol
25 may not be easily performed due to the proprietary nature of the protocol.

 As described further below, embodiments of the present disclosure include a kit that provides hardware and software to enable monitor, debug, and testing of devices operable with a proprietary module and corresponding protocol. Such device may
30 include a medical monitor (also referred to as a "host") configured to receive data from a sensor or other device operable with the module. The kit may enable easier integration

of the module with host and ensure that the host can interpret and display data received from the module.

5 The kit may provide display and interpretation of operation of the module and any communication between the module and a host. The kit may include connections to a sensor device (e.g., a sensor or a sensor simulator) and a host or a host simulator. In this manner, design, debug, and testing may progress from a host simulator to hardware implementation of the host and the module **15**.

10 As mentioned above, the kit may include hardware that enables connection and operation of the module for monitoring and testing. **Fig. 2** depicts an evaluation board **40** that provides for connection of the module **15**, a host, a computer, and other components of a monitoring, debugging, and testing system. The evaluation board **40** may be a printed circuit board assembly **42** that may include a module socket **44**, isolated power supply **46**, non-isolated power supply **48**, a power connection **50**, and various
15 other connections **52**.

During operation of the evaluation board, the module **15** may be installed in the module socket **44**. The module socket **44** provides a connection to the module to enable
20 transfer of data over one or more of the connections **52**. Additionally, the module socket **44** may provide power from the isolated power supply **46** to the module **44**. The isolated power supply **46** may receive power from the power connection **50** and may include an AC to DC converter and may meet any requirements of a medical grade isolated power supply, thus providing accurate power emulation of a medical device having the module.
25 In one embodiment, the isolated power supply **46** may have a leakage current of less than 100 uA at 1500 VAC and may include an isolation barrier between the a non-isolated ground and the isolated ground of greater than 0.190 inches. The non-isolated power supply **48** may receive power from the power connection **50** and may include an AC to DC converter and may provide the evaluation board **40** with DC input power. In one
30 embodiment, the input power may be between 7V and 8V and provide at least 600 mA. The non-isolated power supply **48** may provide DC power to the connectors **52**.

The connections **52** may include any number and type of connections to the enable control and monitoring of the evaluation board **40** and any module installed in the evaluation board **40**. For example, in one embodiment, the connections **52** may include a Universal Serial Bus (USB) connection **52A**, a sensor cable connection **52B**, a serial communications port **52C**, an ECG input port **52D**, and an analog output **52E**. In some embodiments, the ECG input port **52D** may provide a module coupled to the evaluation board **40** with C-LOCK® ECG synchronization. The evaluation board **40** may also include an additional “pick-off” connection **52F** to enable monitoring of a hardware host (such as a medical monitor). It should be appreciated that other embodiments may include any number and combination of the connections described above and may include any other suitable connections.

In some embodiment, the USB connection may provide for connection to one or more serial ports (e.g., USB-serial) on the evaluation board **40**. These additional serial ports may allow for communication to and from a module installed in the module socket **44**. The serial port **52C** and other serial ports may use the same circuitry, but communication over one or more ports may be routed by on-board switches on the evaluation board **40** to prevent message collisions.

Figs. 3-5 depict various system configurations of the evaluation board **40** and other components of a design and testing system to evaluate operation of a host and the module **15**. Each configuration may include use of a sensor device coupled to the evaluation board **40**. Additionally, some configurations may include use of a host simulator, a software host, or a hardware host (e.g., a medical monitor having an integrated module). Each configuration may include different types and numbers of devices coupled to the evaluation board **40**.

Fig. 3 depicts a first system configuration **60** of the evaluation board **40** that includes a computer **62** (e.g., a personal computer such as a desktop, laptop, etc.) coupled to the evaluation board **40**. In the first configuration, the module **15** may be coupled to the evaluation board **40** by the module socket **44**. The evaluation board **40** may be coupled to a power source **63** (e.g., an AC power source, a power adapter coupled to an AC power source, a battery, etc.) The computer **62** may be coupled to the evaluation

board 40 by the USB connection 52A. Alternatively, in some embodiments the computer 62 may be coupled to the evaluation board 40 by the serial communications port 52C.

The evaluation board 40 may also be coupled to a sensor device 64. In one embodiment, the sensor device 64 may be any suitable medical sensor, such as pulse oximetry sensor to enable monitoring of blood-oxygen saturation of a subject. In such an embodiment, the sensor device 64 may be a DS100A sensor, a Max-Fast® sensor, or a Softcare® sensor available from Nellcor Puritan Bennett, LLC. In other embodiments, the sensor device 64 may be a sensor simulator that simulates monitoring of a physiological parameter and provides data to the evaluation board 40 and the module 15. In such an embodiment, the sensor device 64 may be an SRC-MAX Portable Oximetry Tester available from Nellcor Puritan Bennett, LLC.

The computer 62 includes a processor 65, a memory 66, and a display 68. The memory 66 may include volatile memory (e.g., RAM) and non-volatile memory (e.g., flash memory, magnetic storage devices, etc). The computer 62 may include software (e.g., programs) to provide control and/or monitoring of the module 15 and the evaluation board 40. For example, the computer may include a protocol analyzer 70 configured to display, interpret, or otherwise process protocol messages. Additionally, as shown in Fig. 3, the first system configuration 60 may not include a hardware host or a software host. In such a configuration, the computer 62 may execute one or more programs that simulate a host. For example, as shown in Fig. 3, the computer 62 may include a host simulator 72. As described further below, the host simulator 72 simulates a host that communicates with the module 15, generates messages from the module according to the configurations and actions set in the host simulator 72, and displays data received from the module 15. The protocol analyzer 70 and the host simulator 72 may be programmed as executable code stored on a tangible machine readable medium (e.g., the memory 66) accessible by the computer 62. In some embodiments, the protocol analyzer 70 and the host simulator 72 may be encoded on a CD-ROM, diskette, flash drive, or other removable media.

In the first configuration depicted in Fig. 3, a user may monitor two-way communication between the module 15 and the host simulator 72 through the connection to the evaluation board 40. The communication received and sent by the module 15 may be in a specific protocol monitored by the protocol analyzer 70. The protocol analyzer 70 is configured to display protocol messages sent from the host simulator 72 to the module 15 and messages sent from the module 15 to the host simulator 72. The protocol analyzer 70 is configured to parse messages formatted according to the protocol used by the module 15.

Additionally, in some embodiments the protocol analyzer 70 may enable a user to send messages directly to the module 15 and monitor the response from the module 15. A user may also use the host simulator 72 to display the data from the sensor device 64 as interpreted by the module 15. Additionally, the user can set different parameters on the host simulator 72, such as display parameters, alarm settings, sampling rate, etc., and monitor how the module responds and communicates to such parameter settings. Further, a user may change the data provided by the sensor device 64 (such as by adjusting a sensor or sensor simulator) and monitor the communication between the module and the host simulator 72. In this manner, a user may evaluate the operation of the module, in response to different sensor device data or host settings, without a hardware or software host.

Fig. 4 depicts a second system configuration 80 of the evaluation board 40 that enables further development of devices operable with the module. In the second system configuration 80, the evaluation board 40 may be coupled to the computer 62 (e.g., a personal computer such as a desktop, laptop, etc.) that includes the protocol analyzer 70 and the host simulator 72, such as by the USB port 52A. Additionally, the evaluation board 40 may be coupled to the sensor device 64, such as a sensor configured to monitor a physiological parameter or a sensor simulator, by the sensor cable connector 52B. As mentioned above, in some embodiments the sensor may be pulse oximetry sensor and the module 15 may be a pulse oximetry module. The sensor device 64 may be coupled to the evaluation board 40 by a patient interface cable.

As shown in **Fig. 4** a second computer **82** (e.g., a personal computer such as a desktop, laptop, etc., a server, or any other suitable computing device) may be coupled to the evaluation board, such as by the serial communication port **52C**. The second computer **82** may include a processor **84**, memory **86**, and a display **88**. The memory **86** may include volatile memory (e.g., RAM) and non-volatile memory (e.g., flash memory, magnetic storage device, etc). The second computer **82** may include a software host **90**. The software host **90** may include some or all of the components of a hardware medical monitor. The hardware and software components of a hardware host may be emulated by executing the software host **90** on the second computer **82** to enable design, debug, and testing of such components. In some embodiments, as shown in **Fig. 4**, the computer **62** and the computer **82** may be different devices. In other embodiments, a single computer may be coupled to the evaluation board **40** and may execute the protocol analyzer **70**, the host simulator **72**, and the software host **90**.

Using the protocol analyzer **70**, a user may use the second system configuration **80** to monitor communication between the host **90** and the module **15** over the protocol used by the module **15**. As described above, the protocol analyzer **70** can display the protocol messages on the computer **62**. The evaluation board **40** provides routing of messages among the individual devices of the second system configuration **80**. For example, a user may change the data provided by the sensor device **64** (such as by adjusting a sensor or sensor simulator) and monitor the communication between the module **15** and the host **90**. Additionally, a user may change settings on the host **90** and monitor the communication to the module **15** and the response from the module **15**. In some embodiments, a user may send messages to the module **15** and/or the host **90** from the protocol analyzer **70**. Thus, a user may test and debug operability of the host **90** with the module **15**, using the connections provided by the evaluation board **40** and the protocol analyzer **70**.

Fig. 5 depicts a third system configuration **92** of the evaluation board **40** that may be used to evaluate operability of a hardware host, e.g., medical monitor **94** having the module **15** integrated into the monitor **94**. In one embodiment, the medical monitor **94** may be a multi-parameter medical monitor. As discussed above, the computer **62** may be

coupled to the evaluation board 40 by the USB port 52A. The computer 62 may include the protocol analyzer 70 and the host simulator 72 and may enable a user to configure and use the protocol analyzer 70 to monitor the communication to and from the module 15.

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The medical monitor 94 may be coupled to the evaluation board 40 through any available connection 52. In one embodiment, the medical monitor 94 may be coupled to the evaluation board 40 by the pick-off connection 52F. In some embodiments, the medical monitor 94 may be coupled to both the serial port 52B and the pick-off connection 52F using a Y-cable having one end connected to the monitor 94 and two ends coupled to the evaluation board 40. The medical monitor 94 may include a processor 93, memory 96, and a display 98. The memory 96 may include volatile memory (e.g., RAM) and non-volatile memory (e.g., flash memory, magnetic storage device, etc). As shown in Fig. 5, the module 15 may be operably installed in the medical monitor 94 to provide the module functionality to the monitor 94. The medical monitor 94 may also be coupled to the sensor device 64, e.g., a sensor configured to monitor a physiological parameter or a sensor simulator. As mentioned above, in some embodiments, the sensor may be a pulse oximetry sensor and the module 15 may be a pulse oximetry module.

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The medical monitor 94 may receive data from the sensor device 64 for processing by the module 15. The module 15 may provide output to the monitor 94 based on the sensor data and configuration settings of the monitor 94. The communication received and sent by the module 15 may be in a specific protocol monitored by the protocol analyzer 70. A user may view protocol messages between the module 15 and the medical monitor 94 using the protocol analyzer 70, so that the user may monitor, test, and debug the medical monitor 94 and its interaction with the module 15. Additionally, in some embodiments, the protocol analyzer 70 may provide for transmitting messages to the module 15 and/or the medical monitor 94 via the connections to the evaluation board 40. In this configuration 92, a user is able to test and debug a hardware host (monitor 94) that integrates the module 15 by monitoring the protocol messages communicated during operation of the host.

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In should be appreciated that other embodiments may include alternate configurations to those illustrated above in **Figs. 3-5**. Such configurations may include any combination of devices coupled to the evaluation board **40**. Additionally, in other configurations the evaluation board may be coupled to an ECG sensor by the ECG input port **52G**. In other embodiments, an analog device may be coupled to the analog output **52E**.

Fig. 6 depicts a process **100** for use and operation of the evaluation board **40** in accordance with an embodiment of the present disclosure. The process **100** may depict use and operation of the evaluation board **40** in any of the configurations described above in **Fig. 3-5**. As described above, depending on the configuration, the evaluation board **40** may communicate with multiple devices, such as the first computer **62**, the second computer **82**, the sensor device **64**, and/or a medical monitor **94**.

Initially, a user may install the module **15**, such as oximetry module or other medical monitoring module, into the module socket **44** of the evaluation board **40** (block **102**). Next, a user may connect devices to the evaluation board **40** (block **104**). As shown above in **Figs. 3-5**, depending on the desired system configuration, a user may connect the sensor device **64**, the first computer **62**, the second computer **82**, and/or the medical monitor **94** to the evaluation board **40** using the connectors **52** described above.

After connection of devices to the evaluation board, the user may begin generating data from the sensor device **64** (block **106**). For example, if the sensor device **64** is a sensor, a user may place the sensor on a person and generate data corresponding to physiological parameters of the person detected by the sensor. If the sensor device **64** is a sensor simulator, the user may activate the sensor simulator to simulate generation of detected physiological parameter data. In some embodiments, the user may also configure the host or host simulator **72** to display certain information (e.g., physiological parameter data) or execute certain functionality (e.g., alarms). In such embodiments, creation and configuration of the host simulator **72** may be performed using the host simulator **72** executing on the computer **62**.

During operation of the sensor, the module **15** receives data from the sensor device **64**, processes the data, and transmits and receives messages to and from the host or host simulator **72** (block **108**). As described above, the communication between the module **15** and the host or host simulator **72** may be in specific protocol, such as a proprietary protocol of the manufacturer of the module **15**. As discussed above, in one embodiment the module **15** may communicate and format messages in SHIP. Additionally, in some embodiments, the user may send messages to the host and host simulator **72** using the protocol analyzer **70** (block **110**). Further, in some embodiments the user may send messages directly to the module **15** from the protocol analyzer **70** or the host simulator **72** (block **112**).

During or after operation of the evaluation board **40**, a user may display messages sent between the module and the host or host simulator **72** using the protocol analyzer **70** (block **114**). For example, the user may view the messages on the display of the computer **62**. The protocol analyzer **70** may be configured to display a subset of the available messages sent between the module and host or host simulator **72**. For example, if the module **15** communicates using a specific protocol, the protocol analyzer **70** may be configured to only display those protocol messages useful for testing and debugging. Further, the protocol analyzer **70** may be configured to not display messages from the protocol that are undesirable for a user to view. In this manner, only selected messages of a specific protocol may be displayed to a user, without providing a user access to the code defining the protocol.

In some embodiments, as discussed further below, the protocol analyzer **70** may provide processing of messages communicated between the host or host simulator **72** and the module **15**, such as by interpreting or filtering such messages. Additionally, the protocol analyzer **70** may store messages sent between the module and the host or host simulator **72** to a log file stored on the memory **66** of the computer **62**. As discussed further below, this log file may be viewed or printed by a user, and may be used to playback messages to the module **15**.

Figs. 7-12 are a flowchart and screenshots that depict operation of the protocol analyzer **70**. As described further below, the protocol analyzer **70** provides for display of messages sent between the module **15** (either installed in the evaluation board **40** or integrated into a host) and a host (e.g., second computer **82** or monitor **94**) or host simulator **72**, and to transmit messages to the module **15**. Additionally, the protocol analyzer **70** provides filtering, parsing, and logging of such messages.

Turning now to operation of the protocol analyzer **70**, **Fig. 7** is a flowchart **120** depicting operation of the protocol analyzer **70** in accordance with an embodiment of the present disclosure. Initially, the protocol analyzer **70** may be used to configure connections to the evaluation board **40** and the module **15** (block **122**). For example, as discussed above, the computer **62** executing the protocol analyzer **70** may be coupled to the evaluation board **40** by the USB connection **52C**. The protocol analyzer **70** may enable configuration of resources of the computer **62** to enable communication to and from the evaluation board **40** (and the module **15**) and the computer **62**. Additionally, the protocol analyzer **70** may be used to configure a connection to the host (block **124**). For example, the protocol analyzer **70** may be configured to connect to the second computer **82** or the medical monitor **94**. In some embodiments, as described above, the host simulator **72** may be included on the computer **62** that includes the protocol analyzer **70**. In such embodiments, the host simulator **72** may be a part of the protocol analyzer **70**, or the protocol analyzer **70** may automatically configured to communicate with the host simulator **72**. In other embodiments, the host simulator **72** may execute on a different computer coupled to the evaluation board **40**.

The protocol analyzer **70** may be used to transmit messages to the module (block **126**), monitor messages sent to the module **15** (block **128**), and monitor messages sent from the module **15** (block **130**). Any one of or combination of these functions may be used during testing and debug of the host or host simulator **72** and the module **15**. If the protocol analyzer **70** is used to transmit messages to the module, the protocol analyzer **70** may also include the capability to playback log files as messages sent to the module (block **132**). The log files may include previously stored messages sent to or received

from the module 15. A user may playback a log file to determine how the module 15 responds to the messages recorded in the log file.

During or after display of messages sent to and received from the module 15, the
5 protocol analyzer 70 may filter messages based on any specified criteria (block 134).
The filtering may include filtering by any specified criteria and may include filtering by
pattern found in the content of a message. Additionally, the protocol analyzer 70 may
parse messages sent between the module and the host or host simulator 72 (block 136).
The parsing may include interpreting messages that have been formatted according to the
10 protocol used between the module and the host or host simulator 72. Additionally, as
noted above, the protocol analyzer 70 may enable storing of messages sent between the
module and the host or host simulator 72 to a log file (block 138).

Fig. 8 is a screenshot of an interface screen 140 of the protocol analyzer 70 in
15 accordance with an embodiment of the present disclosure. Fig. 8 depicts a first set of
menus 142 that provide configuration of the connection to the module 15, such as
selection of a serial port 144 (e.g., selection of the COM ports available on the computer
62) and selection of a baud rate 146, and a button 148 for initiating or disconnecting the
connection to the module 15. Additionally, Fig. 8 also depicts a second set of menus 150
20 that provide for configuration of connection to the host, such as selection a serial port
152, selection of a baud rate 154, and selection of a button 156 for initiating or
disconnecting the connection to the host.

As mentioned above, in some embodiments the protocol analyzer 70 may provide
25 for transmitting of messages to the module 15 and/or to the host or host simulator 72
coupled to the evaluation board 40. Fig. 9 depicts an interface screen 160 illustrating
such functionality in accordance with an embodiment of the present disclosure. The
interface screen 160 may include a message display area 161 and radio buttons 162 for
selection of a write connection. The interface screen 160 includes a dialog box 164 and
30 corresponding "Send Msg" button 166 and "Raw" button 168 for transmitting messages
to the module 15. The interface screen 160 also includes a dialog box 170 and
corresponding "Send Msg" button 172 and "Raw" button 174 for transmitting messages

to the host. For example, as shown in **Fig. 9**, a user may send messages to the module by entering text “56 00” in the dialog box **164** and selecting the “Send Msg” button **166**.

The protocol analyzer **70** may format the message according to the protocol used by the module **15** and transmit the message to the module **15**. The message display area **161**

5 may display the results of the send action and the formatted message (e.g., the contents of the protocol packet) sent to the module **15**. A user may also send unformatted messages (i.e. messages not formatted to any protocol) of the text in the dialog box **164** by selecting the “Raw” button **168**. Similarly, a user may send formatted and unformatted messages to the host using the “Send Msg” button **172** and the “Raw” button **170**.

10

Fig. 10 depicts an interface screen **180** of the protocol analyzer **70** illustrating monitoring of messages sent between the module and the host (or host simulator **72**) in accordance with an embodiment of the present disclosure. A display area **182** of the interface screen **180** may display the messages sent between the module and the host.

15 Additionally, a user may filter the messages displayed by selecting items from a first set of checkboxes **184** and a second set of checkboxes **186**. The first set of checkboxes **182** may enable a user to select display of all messages sent from the module **15** and/or messages sent from the host. The second set of checkboxes **186** may enable a user to select display of messages that only contain the selected message key (e.g., “V”, “E”, “I”,
20 etc. as shown in **Fig. 10**). The display area **182** may display the time (column **190**, also referred to as the “timestamp”) of the message (or, additionally, the date of the message), the direction (column **192**) of the message, and the contents (column **194**) of the message.

25 **Fig. 11** depicts an interface screen **200** of the protocol analyzer **70** illustrating filtering of messages in accordance with an embodiment of the present disclosure. The interface screen **200** includes a “MsgFilter” dialog box **202** that enables a user to filter messages based on text entered in the dialog box **202**. The display area **204** of the interface screen **202** shows the messages having content that matches the specified
30 sequence entered in the dialog box **202**. For example, each message shown in the display area **204** includes the sequence “6a 06 d4” entered in the “MsgFilter” dialog box **202**.

Fig. 12 depicts an interface screen **210** depicting parsing of messages by the protocol analyzer **70** in accordance with an embodiment of the present disclosure. The contents of monitored messages and the parsed output may be displayed in a display area **212** of the interface screen **210**. The parsing functionality may be activated by selecting a checkbox **214**. After activating message parsing, the protocol analyzer **70** may parse the message contents **216** and display text **218** corresponding to the contents of the message. In some embodiments, the protocol analyzer **70** may include a lookup table, database, or other storage component that stores text corresponding to different message contents for the protocol used by the module **15**.

Turning now to the host simulator **72**, **Fig. 13** is a flowchart **220** depicting operation of the host simulator **72** in accordance with an embodiment of the present disclosure. As described above, the host simulator **72** may execute on the computer **62** that is coupled to the evaluation board **40**. The host simulator **72** provides a simulated host to allow a user to monitor, test, and debug messages sent between the simulated host and the module **15**, without using a software host on another computer or a hardware host.

Initially, a user may configure settings for the host simulator **72** (block **222**). The configuration may include selecting the connection to the evaluation board **40** (and the module **15**) and configuring display settings. As also described above, the host simulator **72** may be used to transmit messages directly to the module (block **224**). The user may select any number and/or type of messages to send to the module. Additionally, the host simulator **72** may provide for a “query” function to query the module **15** and receive the settings from the module **15**. In some embodiments, such messages may include alarm settings (e.g., SpO2 high and low settings, pulse rate high and low settings, etc.), enabling and disabling sensor adjust messages, and/or any other settings stored, used, and/or accessible by the module. Additionally, the host simulator **72** displays data from the module (block **226**), such as would be displayed on a hardware host (e.g., a medical monitor).

Fig. 14 depicts a display screen **230** of the host simulator **72** in accordance with an embodiment of the present disclosure. The display screen **230** simulates the display screen of a hardware host (e.g., a medical monitor) such that the host simulator **72** allows a user to view changes of a host display in response to the messages received from and sent to the module **15**. The display screen **230** may include display of a waveform **232** (e.g., a plethysmographic waveform) that corresponds to the physiological parameter measured or simulated by the sensor device **64** after processing by the module. The display screen **230** may also include additional graphical or numeric displays **234** that also display data processed by the module **15**. Some or all of the graphical or numeric displays **234** may correspond to data received from the sensor device and processed by the module **15** (such as data corresponding to a physiological parameter), and/or data stored in or generated by the module in response to messages sent from the protocol analyzer **70** or the host simulator **72** (such as alarm data). For example, as shown in **Fig. 14**, the graphical displays may include a blip display **234A**, an alarm display (such as a SatSeconds® display **234B**), an SpO2 indicator **234C**, a beats-per-minute (BPM) indicator **234D**, and display area for other messages **234E** (e.g., alarm messages, sensor adjust messages, etc.).

While the disclosure may be susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and have been described in detail herein. However, it should be understood that the embodiments provided herein are not intended to be limited to the particular forms disclosed. Rather, the various embodiments may cover all modifications, equivalents, and alternatives falling within the spirit and scope of the disclosure as defined by the following appended claims.

CLAIMS

What is claimed is:

1. A device, comprising:
5 a printed circuit board assembly comprising:
a plurality of connections comprising at least one of a universal
serial bus connection, a serial port connection, and a medical sensor connection;
a socket configured to receive a medical monitoring module; and
an isolated power supply configured to supply power to the socket.
10
2. The device of claim 1, wherein the plurality of connections comprises a power
connection, an analog output, an ECG sensor connection, or any combination thereof.
3. The device of claim 1, wherein the medical monitoring module comprises a pulse
15 oximetry module.
4. The device of claim 1, wherein the medical sensor connection is configured to
couple to a pulse oximetry sensor.
- 20 5. The device of claim 1, comprising a non-isolated power supply configured to
supply power to one or more of the plurality of connections.
6. A method, comprising:
receiving data from a sensor device coupled to an evaluation board;
25 providing the data to a medical monitoring module coupled to the evaluation
board; and
sending data in a first protocol from the medical monitoring module to a first
device coupled to the evaluation board.
- 30 7. The method of claim 6, wherein the first device comprises a computer comprising
a host simulator.

8. The method of claim 6, wherein the first device comprises a computer comprising a software host.
9. The method of claim 6, comprising receiving data from a medical monitor
5 coupled to the evaluation board.
10. The method of claim 6, wherein the first protocol comprises Standard Host Interface Protocol.
- 10 11. The method of claim 6, wherein the medical monitoring module comprises a pulse oximetry module.
12. The method of claim 6, wherein the sensor device comprises a sensor simulator.
- 15 13. The method of claim 6, wherein the sensor device comprises a pulse oximetry sensor.
14. An evaluation board for a medical monitoring module, comprising:
a socket configured to receive a medical monitoring module;
20 a medical monitoring module installed in the socket, wherein the evaluation board provides power to the medical monitoring module and further provides communication to the medical monitoring module from a plurality of devices, wherein the plurality of devices comprises a sensor device.
- 25 15. The evaluation board of claim 14, comprising a plurality of connections, where one or more one of the plurality of connections is coupled to a respective one or more of the plurality of devices.
16. The evaluation board of claim 14, comprising an isolated power supply configured to provide power to the medical monitoring module.
- 30 17. The evaluation board of claim 14, comprising a non-isolated power supply to provide power to the plurality of connections.

18. The evaluation board of claim 14, wherein the communication comprises messages sent in first protocol to at least one of the plurality of devices.
- 5 19. The evaluation board of claim 14, wherein the medical monitoring module comprises a pulse oximetry module.
20. The evaluation board of claim 19, wherein the sensor device comprises a pulse oximetry sensor.

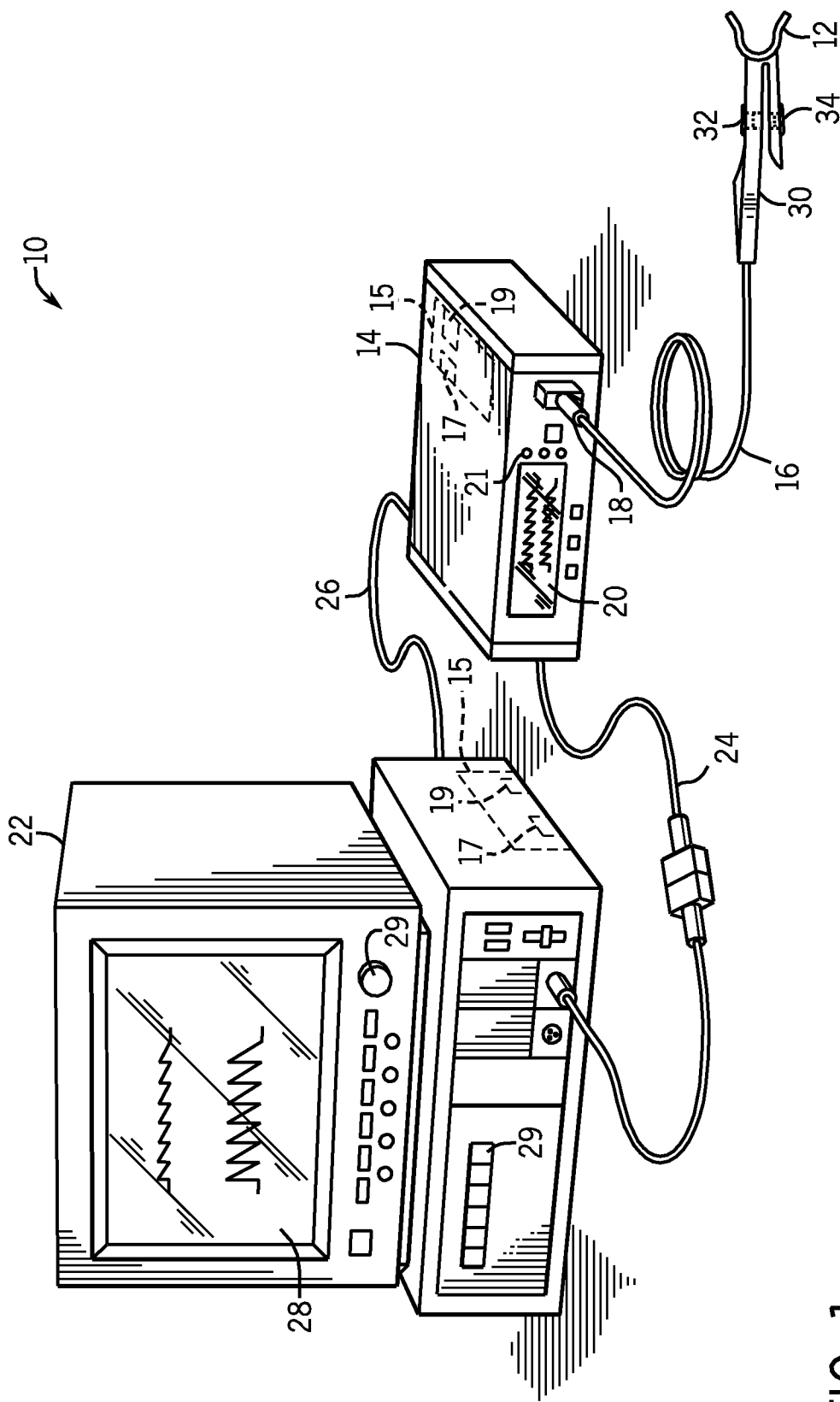


FIG. 1

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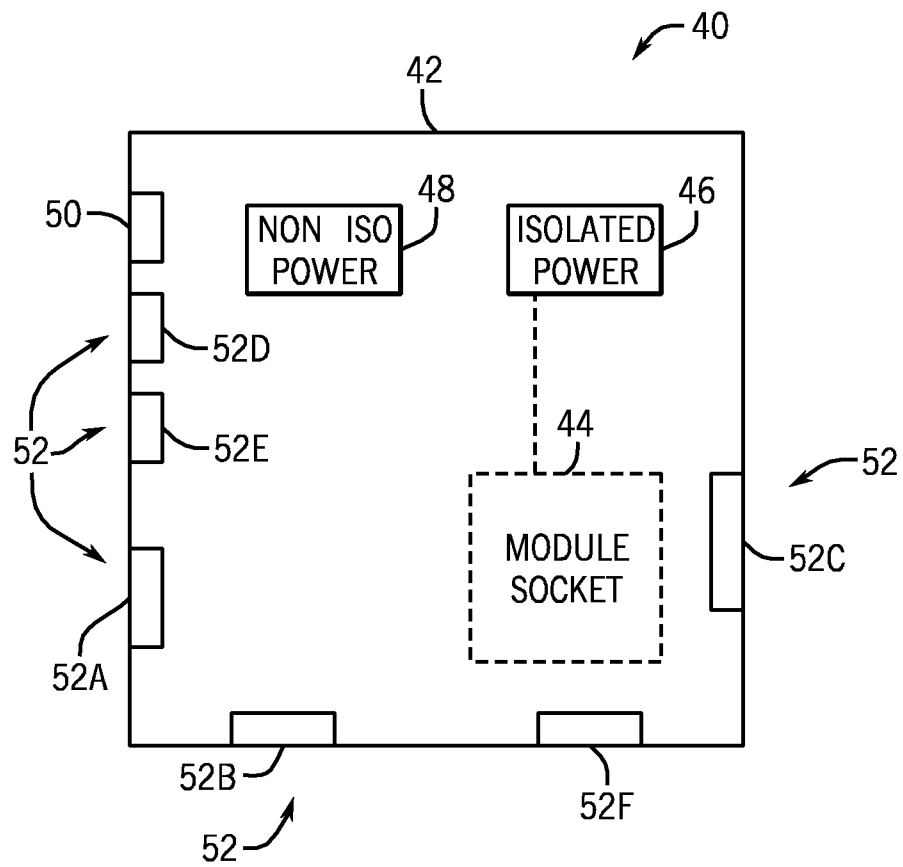


FIG. 2

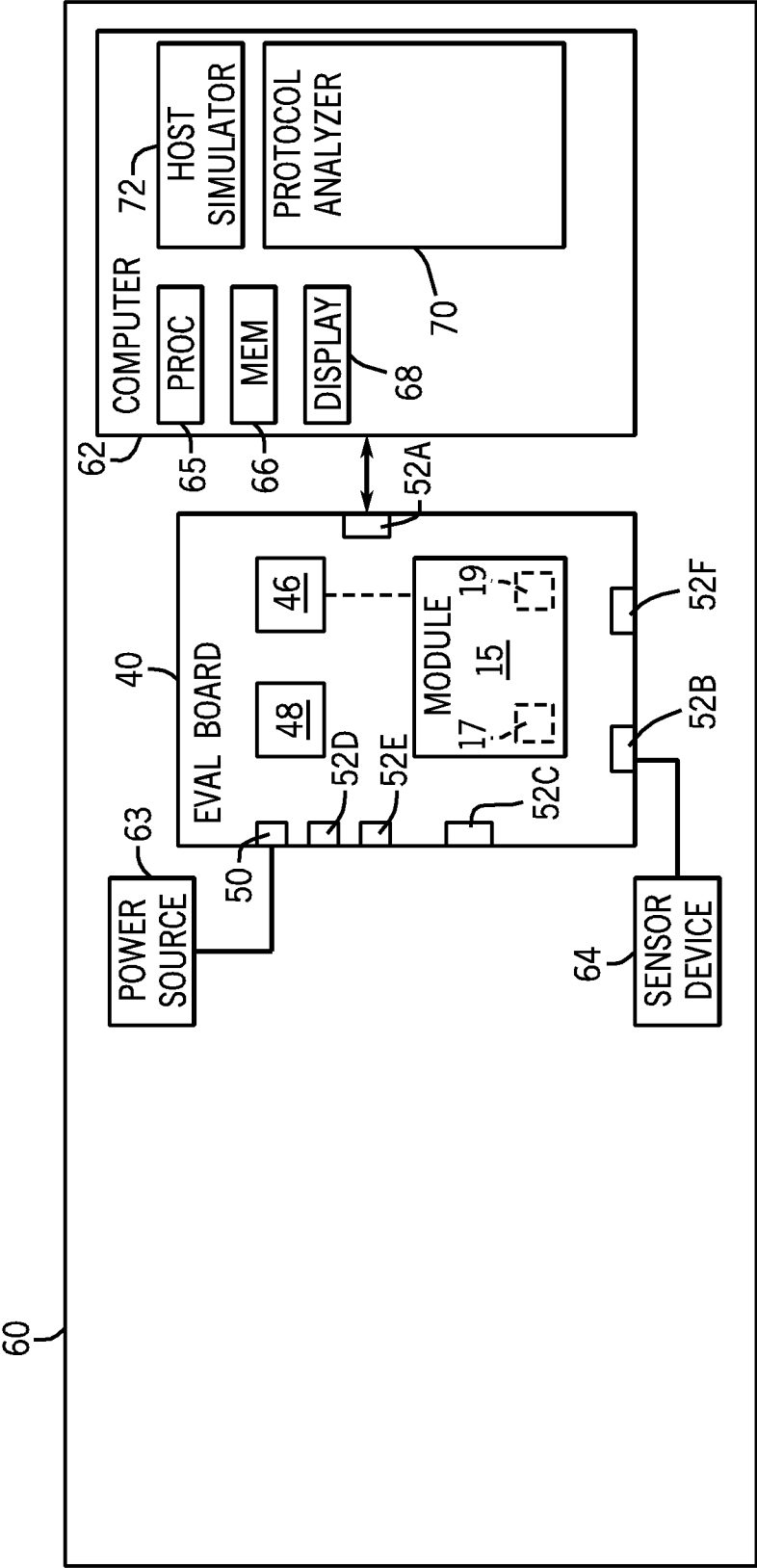


FIG. 3

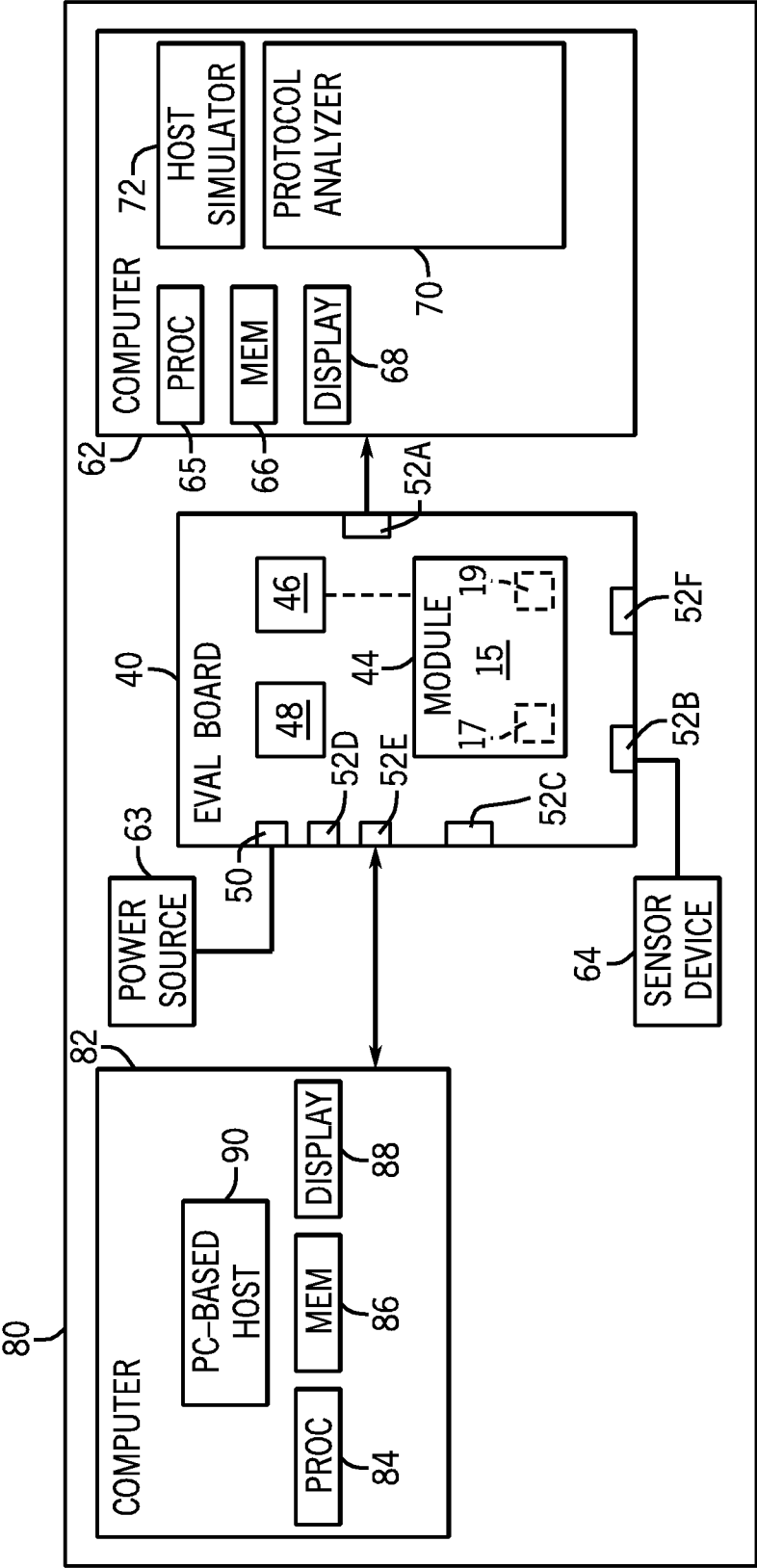


FIG. 4

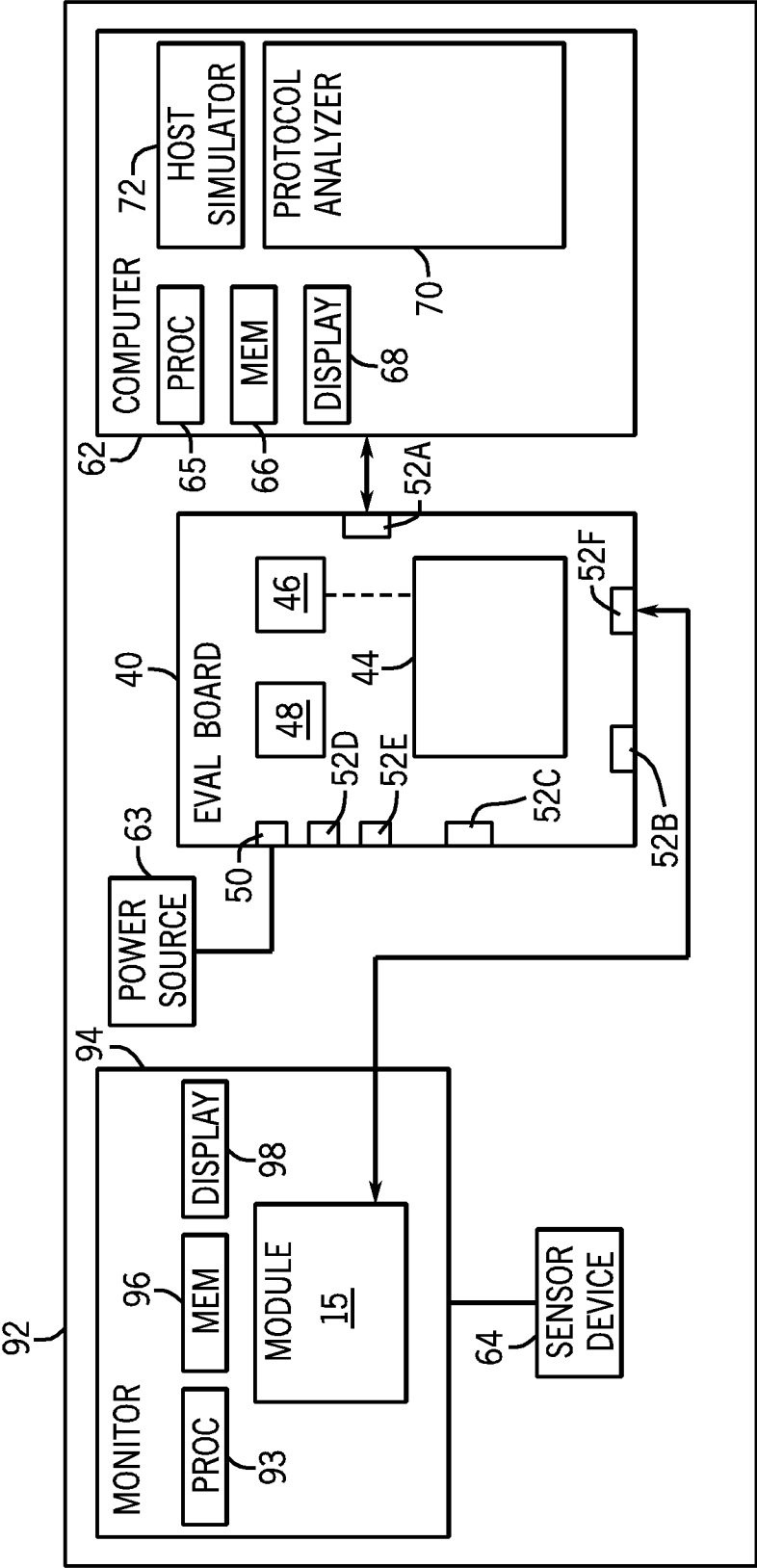


FIG. 5

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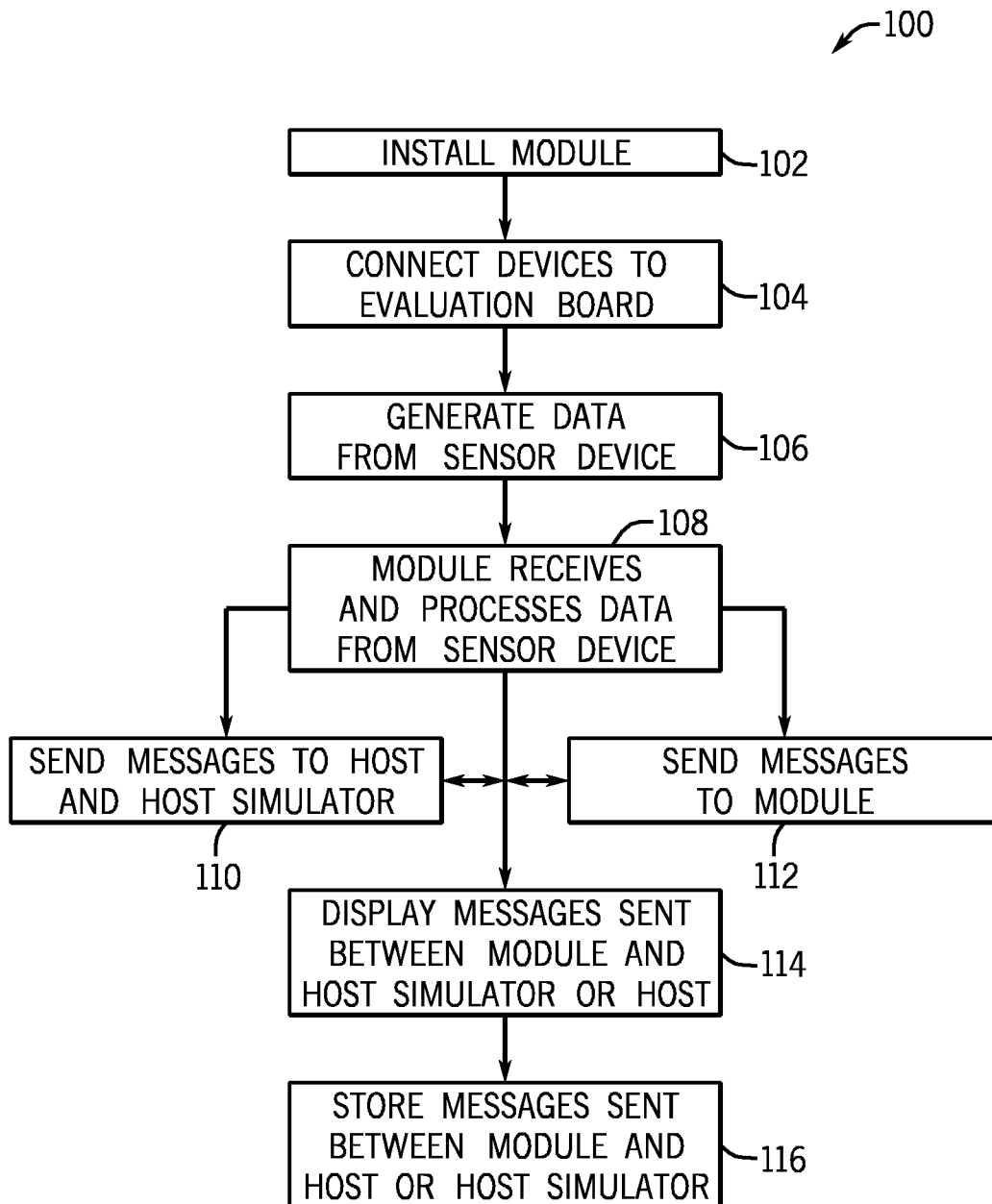
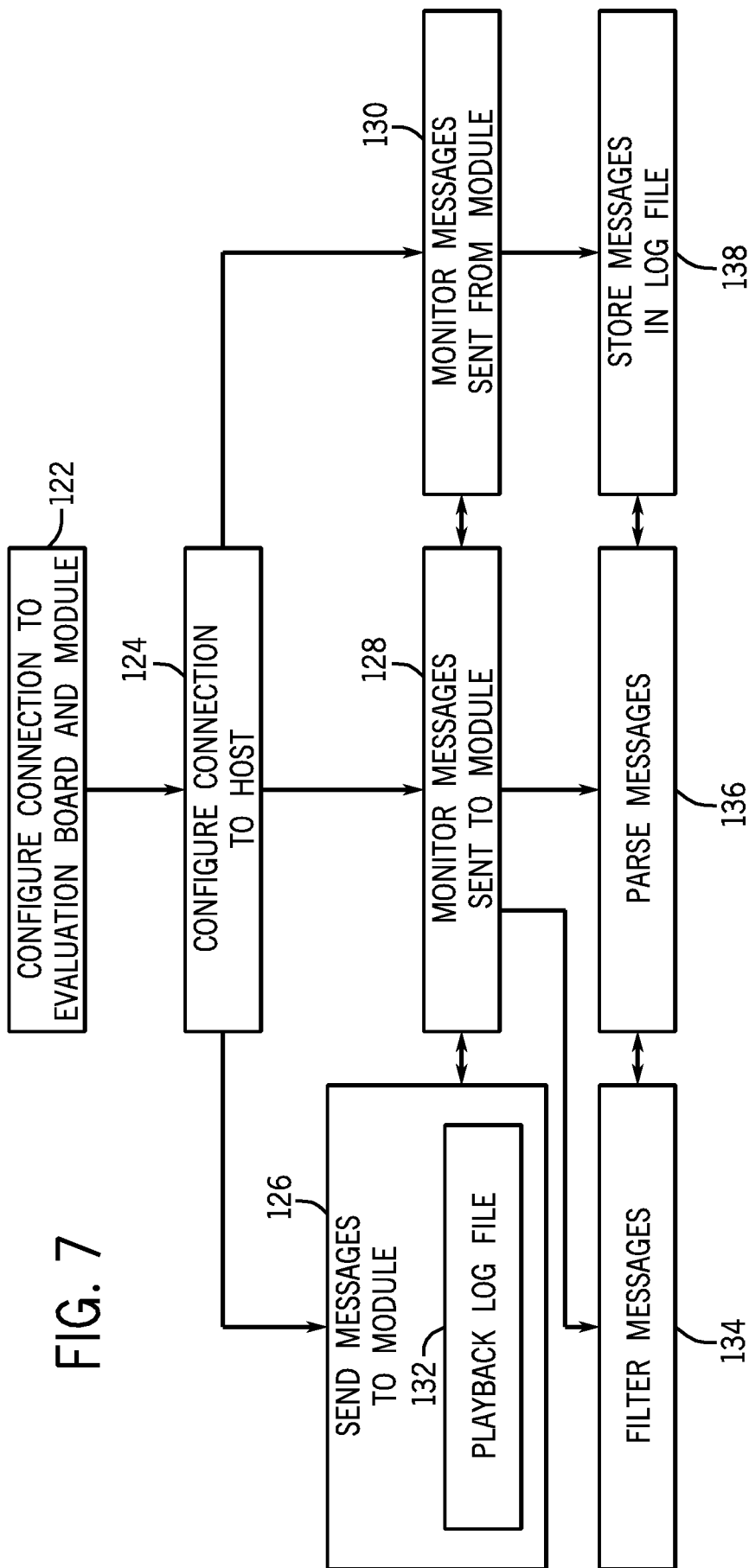


FIG. 6

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120 ↗



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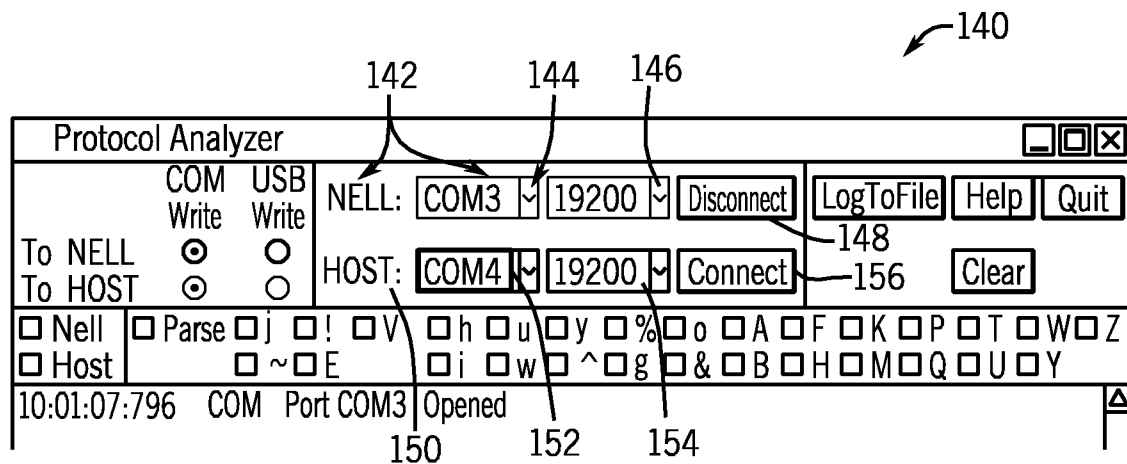


FIG. 8

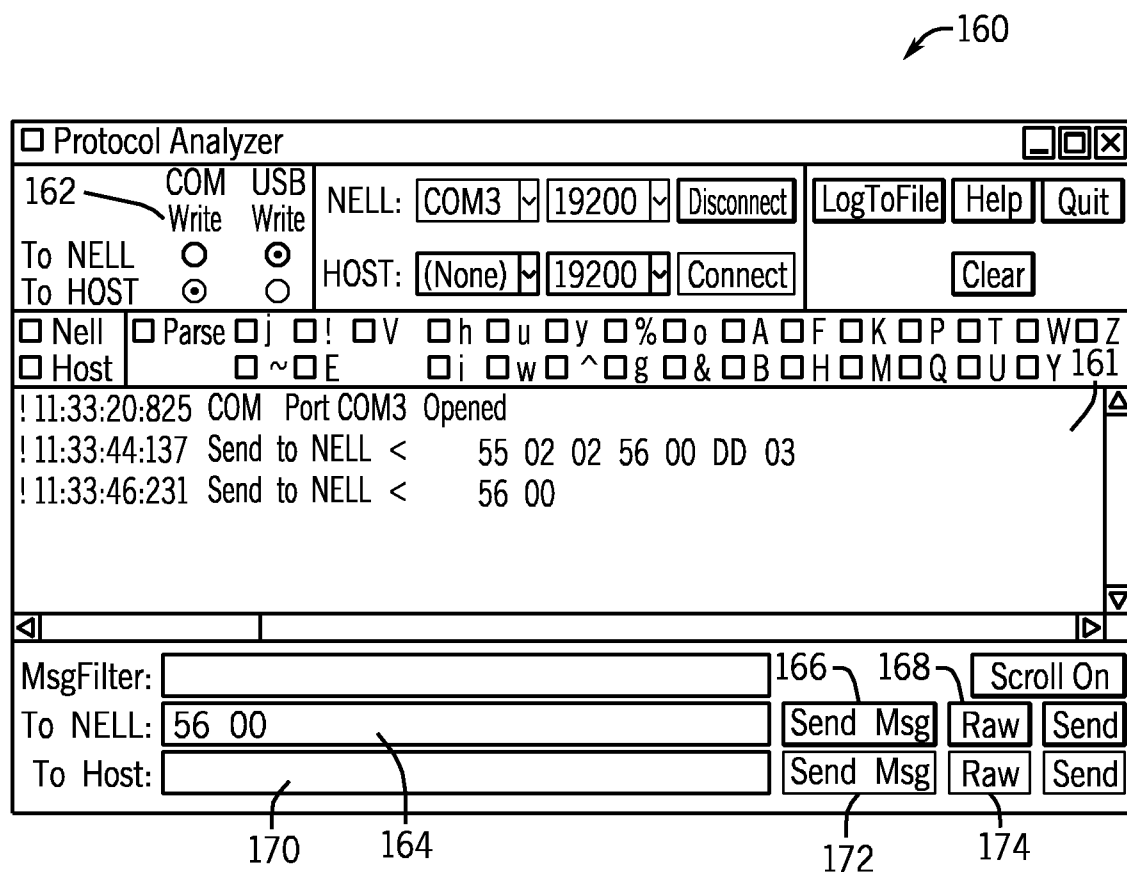


FIG. 9

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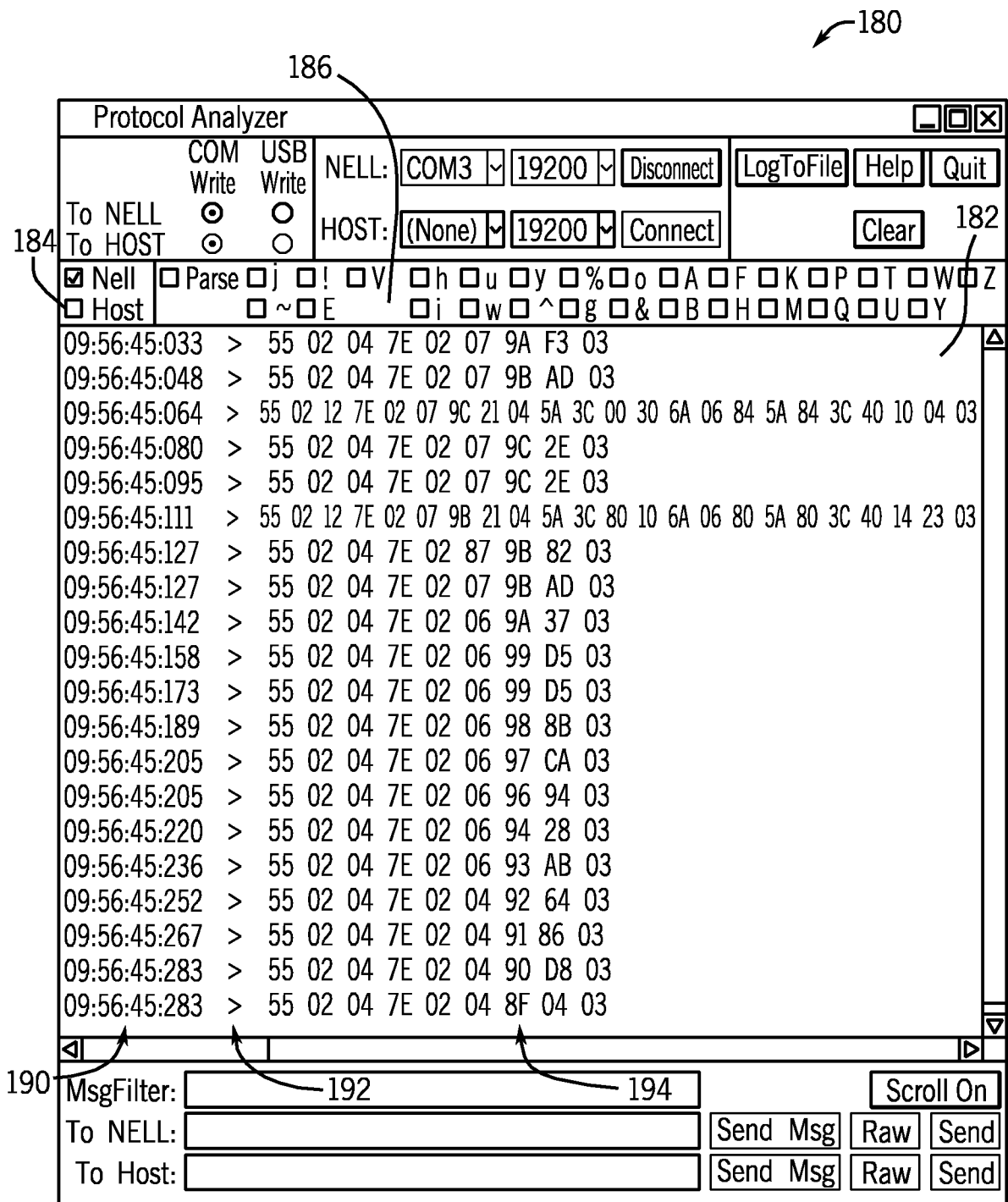


FIG. 10

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200

Protocol Analyzer

COM Write USB Write

NELL: COM6 19200 Disconnect LogToFile Help Quit

To NELL To HOST

HOST: COM7 19200 Disconnect Clear

☐ Nell ☐ Parse ☐ j ☐ ! ☒ V ☐ h ☐ u ☐ y ☐ % ☐ o ☐ A ☐ F ☐ K ☐ P ☐ T ☐ W ☐ Z

☐ Host ☐ ~ ☐ E ☐ i ☐ w ☐ ^ ☐ g ☐ & ☐ B ☐ H ☐ M ☐ Q ☐ U ☐ Y

16:11:01:640 > *55 02 12 7E 02 04 9C 21 04 5A 3B 00 30 6A 06 D4 5A 84 3B 40 12 78 03
6A 06 D4 5A 84 3B 40 12

16:11:02:639 > *55 02 12 7E 02 04 90 21 04 5A 3A 00 30 6A 06 D4 5A 84 3A 40 12 50 03
6A 06 D4 5A 84 3A 40 12

16:11:03:639 > *55 02 12 7E 02 04 8C 21 04 5A 3B 00 30 6A 06 D4 5A 84 3B 40 12 B0 03
6A 06 D4 5A 84 3B 40 12

MsgFilter: 6a 06 d4

To NELL: Send Msg Raw Send

To Host: Send Msg Raw Send

Scroll On

FIG. 11

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210

☐ Protocol Analyzer [Min] [Max] [Close]

COM Write To NELL To HOST	USB Write ☐ ☒	NELL: COM6 19200 Disconnect	HOST: COM7 19200 Disconnect	LogToFile Help Quit
				212

☐ Nell ☒ Parse ☐ j ☐ ! ☐ V ☐ h ☐ u ☐ y ☒ % ☐ o ☐ A ☐ F ☐ K ☐ P ☐ T ☐ W ☐ Z
☐ Host ☐ ~ ☐ E ☐ i ☐ w ☐ ^ ☐ g ☐ & ☐ B ☐ H ☐ M ☐ Q ☐ U ☐ Y

! 10:55:11:557 Send to NELL < 55 02 02 25 00 3E 03

10:55:11:573 < 55 02 02 25 00 3E 03

25 00

214

[%]=25 [0x00]=00

10:55:11:588 > 55 02 08 7E 02 06 9A 25 02 0F 00 68 03

25 02 0F 00

[%]=25 [0x02]=02 [0x0F]=0F [0x00]=00

Sent by the NELL-1 in response to query

! 10:55:15:721 Send to NELL < 55 02 04 25 02 F0 00 27 03

10:55:15:721 < 55 02 04 25 02 F0 00 27 03

25 02 F0 00

[%]=25 [0x02]=02 [0xF0]=F0 [0x00]=00

Sent by the Host to enable Percent Modulation reporting

10:55:16:719 > 55 02 07 7E 02 04 8E 25 01 05 4B 03

25 01 05

[%]=25 [0x01]=01 [IR%Mod]=05

10:55:17:717 > 55 02 07 7E 02 04 8F 25 01 05 C4 03

25 01 05

[%]=25 [0x01]=01 [IR%Mod]=05

! 10:55:18:668 Send to NELL < 55 02 04 25 02 0F 00 A6 03

10:55:18:699 < 55 02 04 25 02 0F 00 A6 03

25 02 0F 00

[%]=25 [0x02]=02 [0x0F]=0F [0x00]=00

Sent by the Host to disable Percent Modulation reporting

MsgFilter:

To NELL:

To Host:

FIG. 12

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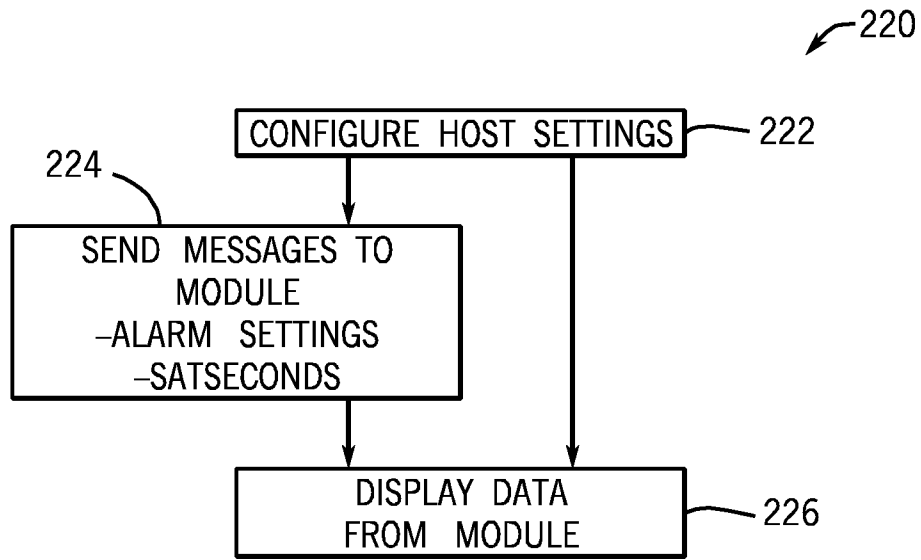


FIG. 13

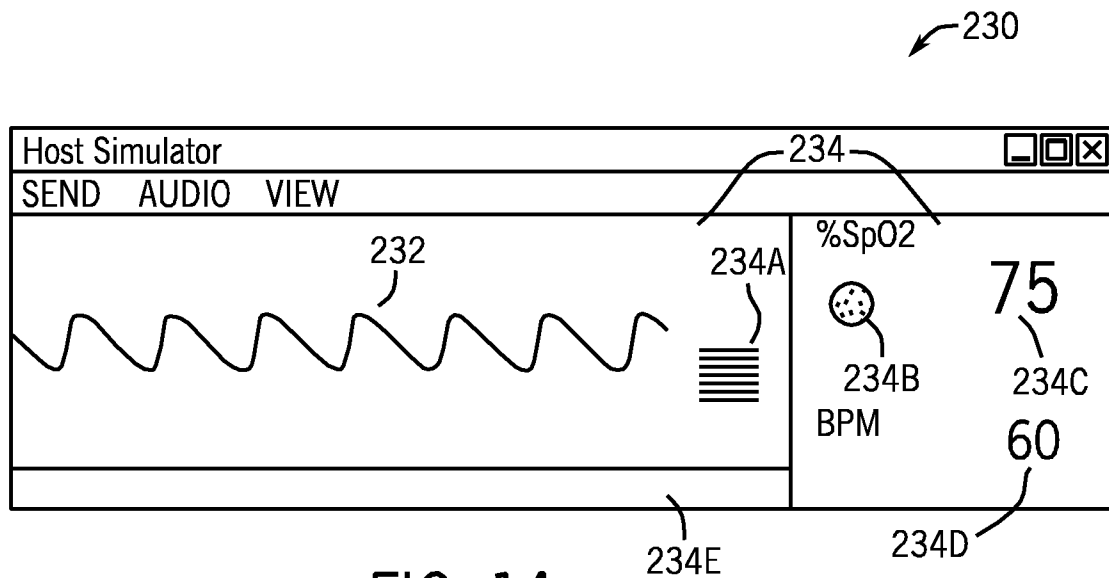


FIG. 14

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2010/042624

A. CLASSIFICATION OF SUBJECT MATTER

INV. G06F19/00 G01R31/28

ADD.

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)

G06F G01R

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 375 604 A (KELLY CLIFFORD M [US] ET AL) 27 December 1994 (1994-12-27) the whole document	1-20
A	US 2009/105983 A1 (VARIYAM PRAMOD [US] ET AL) 23 April 2009 (2009-04-23) the whole document	1-20
A	US 2004/189281 A1 (LE CHANH [US] ET AL) 30 September 2004 (2004-09-30) the whole document	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"E" earlier document but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"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

16 November 2010

Date of mailing of the international search report

30/11/2010

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
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Fax: (+31-70) 340-3016

Authorized officer

Chabros, Cezary

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2010/042624

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
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			DE 69308322 T2	17-07-1997
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			JP 3494648 B2	09-02-2004
			WO 9413198 A1	23-06-1994
US 2009105983	A1	23-04-2009	NONE	
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