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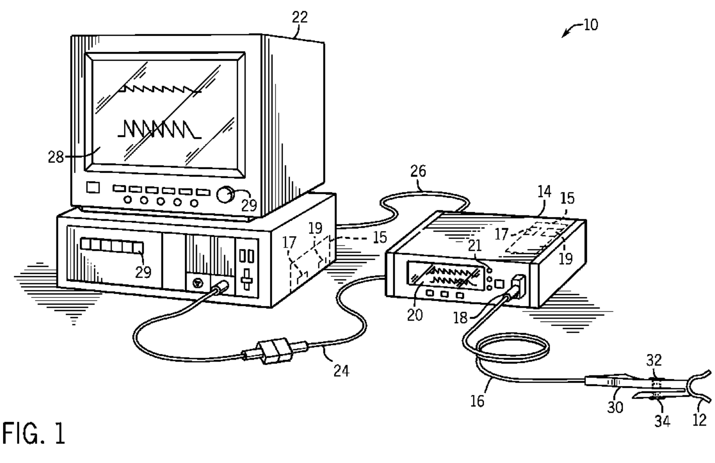

FIG. 1

(57) Abstract: An evaluation kit for monitoring, testing, and debugging a medical monitoring module is provided. The kit includes a hardware and software to provide for monitoring of communication between the medical monitoring module and a host or host simulator. The kit may provide for various system configurations having a sensor device, a computer having a protocol analyzer and a host simulator, a medical monitoring module, a software host, a medical monitor, or any combination thereof.

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EVALUATION KIT FOR MEDICAL MONITORING MODULE SYSTEM AND METHOD

BACKGROUND

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

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.

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.

BRIEF DESCRIPTION OF THE DRAWINGS

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 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 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.).

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 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 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 embodiment, the protocol implemented by the module **15** may by 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 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 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.

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**.

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 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 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 medial grade isolated power supply, thus providing accurate power emulation of a medical device having the module. 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 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 **52**C 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 **52**A. Alternatively, in some embodiments the computer **62** may be coupled to the evaluation board **40** by the serial communications port **52**C.

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 **52**A. 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**.

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.

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.

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 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 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 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** 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 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 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** 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**.

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. 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", "!", 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.

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 sequence entered in the dialog box **202**. For example, each message shown in the display are **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 system, comprising:

an evaluation board comprising a socket and a plurality of connections;

a medical monitoring module coupled to the evaluation board by the socket;

a sensor device coupled to the evaluation board by first one of the plurality of connections;

a first computer coupled to the evaluation board, wherein the computer comprises a protocol analyzer configured to monitor communication in a first protocol to the medical monitoring module and from the medical monitoring module.

2. The system of claim 1, wherein the first computer comprises a host simulator configured to communicate in the first protocol with the medical monitoring module.

3. The system of claim 2, wherein the host simulator is configured to display data received from the medical monitoring device on a display of the first computer.

4. The system of claim 1, comprising a second computer coupled to the evaluation board, wherein the second computer comprises a software host configured to communicate in the first protocol with the medical monitoring module.

5. The system of claim 1, wherein the sensor device comprises a sensor configured to monitor a physiological parameter.

6. The system of claim 5, wherein the medical monitoring module receives data from the sensor and provides data based on the physiological parameter.

7. The system of claim 6, wherein the medical monitoring module provides a plethysmographic waveform.

8. The system of claim 1, wherein the sensor comprises a pulse oximetry sensor.

9. The system of claim 1, wherein the sensor device comprises a sensor simulator configured to simulate monitoring of a physiological parameter.

10. The system of claim 1, wherein the first protocol comprises Standard Host Interface Protocol.

11. The system of claim 1, wherein the plurality of connections comprise a power connector, a universal serial bus connector, a serial port connector, a medical sensor connector, or a combination thereof.

12. The system of claim 1, wherein the evaluation board comprises an isolating power supply configured to supply power to the medical monitoring module.

13. The system of claim 1, wherein the medical monitoring module comprises a pulse oximetry module.

14. A system, comprising:

an evaluation board comprising a socket and a plurality of connections;

a medical monitor coupled to the evaluation board by a first one of the plurality of connections, wherein the medical monitor comprises a medical monitoring module configured to communicate in a first protocol with the medical monitor; and

a first computer coupled to the evaluation board, wherein the computer comprises a protocol analyzer configured to monitor communication in the first protocol to the medical monitoring module and from the medical monitoring module;

15. The system of claim 14, comprising a sensor coupled to the medical monitor and configured to monitor a physiological parameter.

16. The system of claim 14, wherein the sensor comprises a pulse oximetry sensor.

17. The system of claim 14, wherein the medical monitoring module comprises a pulse oximetry module.

18. The system of claim 14, wherein the medical monitor comprises a multi-parameter medical monitor having a second plurality of connections.

19. A method, comprising:

monitoring communication in a first protocol between a medical monitoring module and a first computer, wherein the medical monitoring module is coupled to an evaluation board by a first connection and the first computer is coupled to the medical monitoring module; and

displaying communication between the medical monitoring module and the first computer on a display of the first computer.

20. The method of claim 19, wherein displaying communication comprises parsing messages in the first protocol.

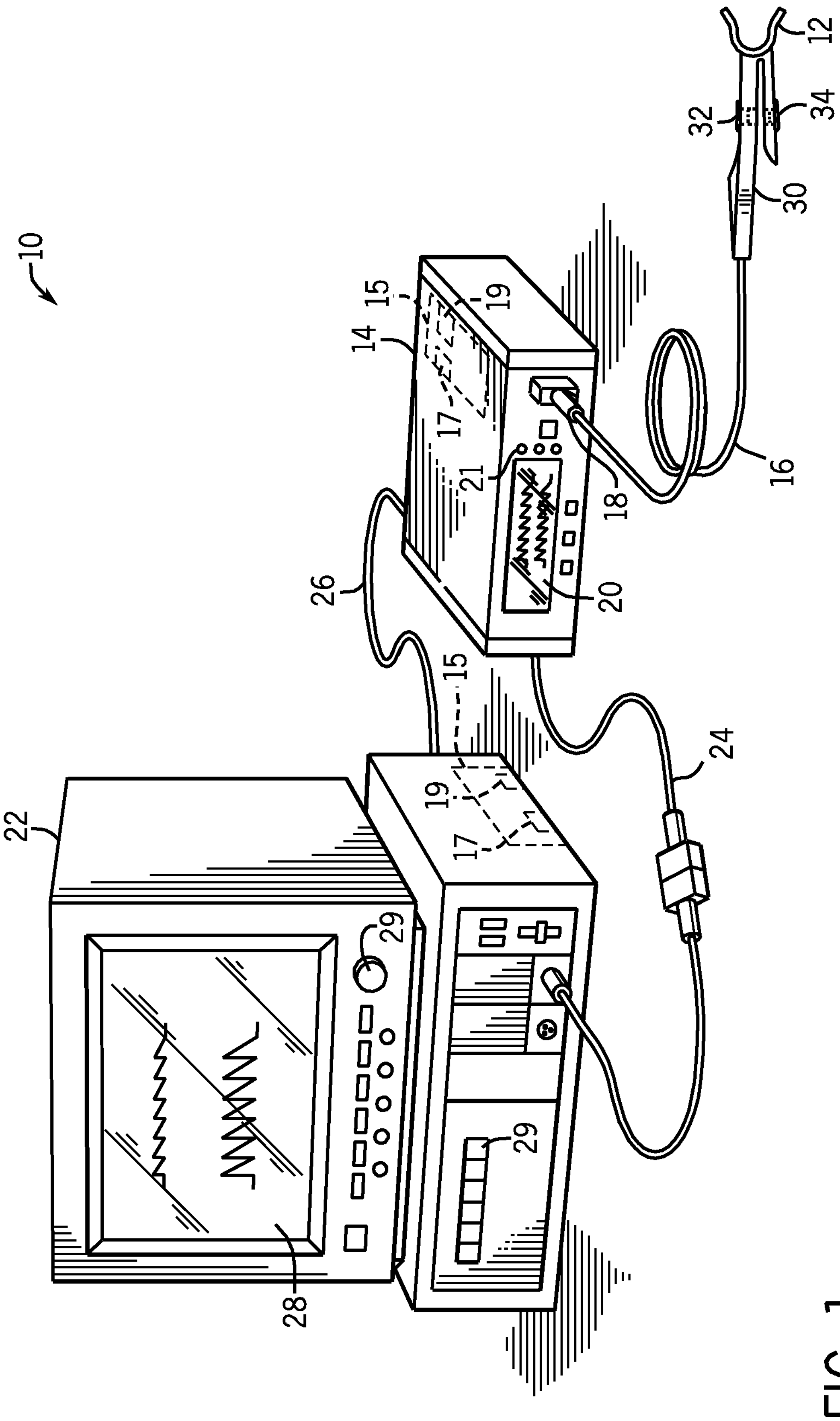


FIG. 1

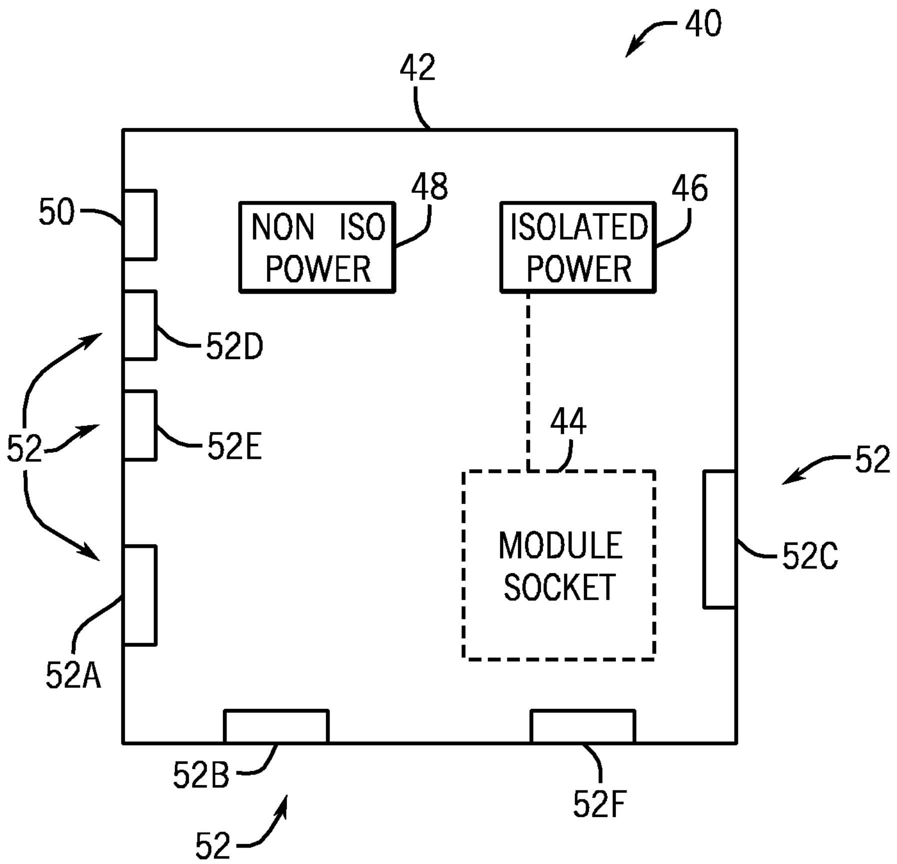
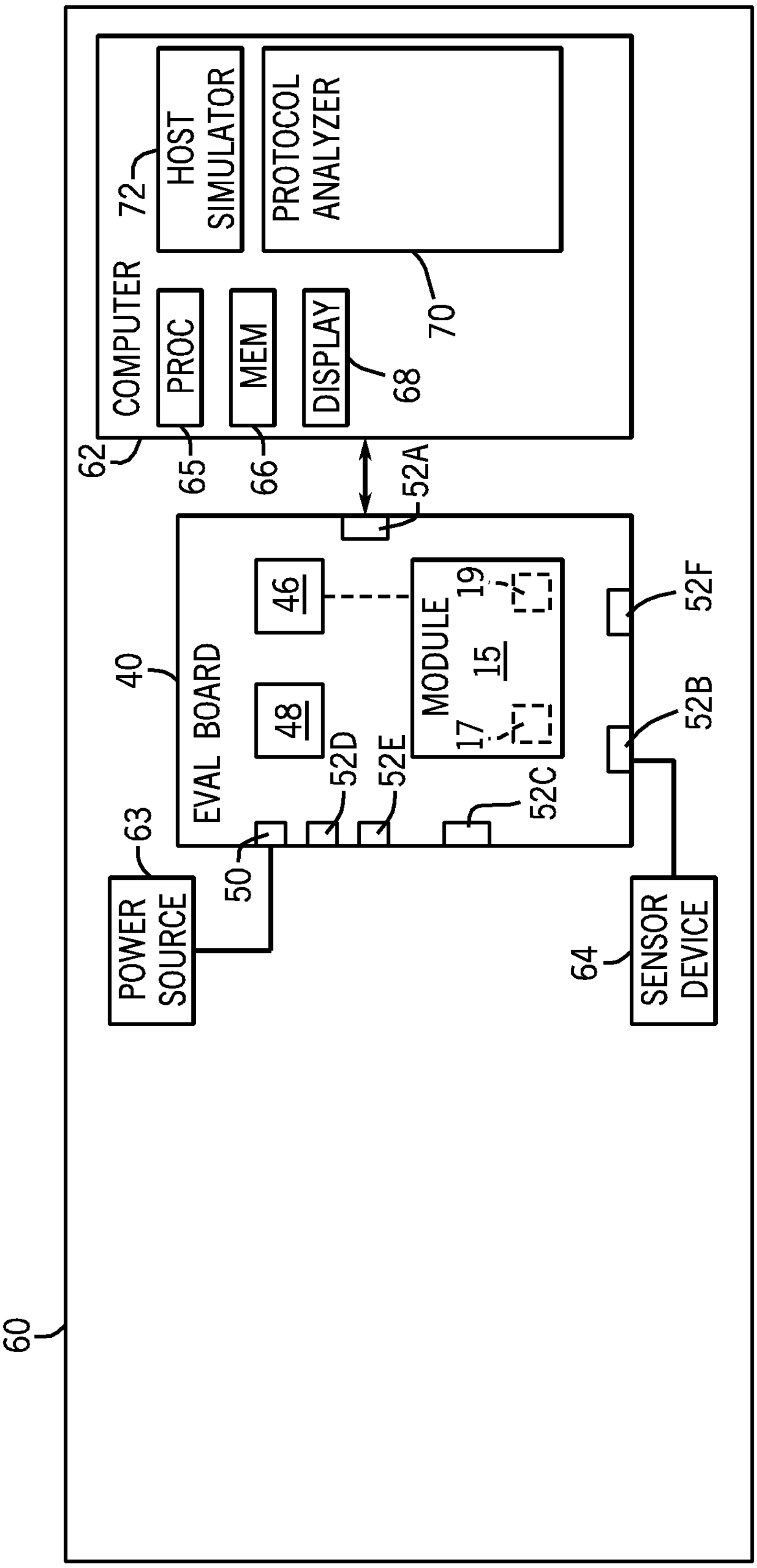

40
42
50
NON ISO
POWER
48
ISOLATED
POWER
46
52D
52E
52
44
MODULE
SOCKET
52C
52A
52B
52F

FIG. 2



60
62
COMPUTER
PROC
65
MEM
66
DISPLAY
68
72
HOST SIMULATOR
PROTOCOL ANALYZER
70
52A
40
EVAL BOARD
48
46
MODULE
15
17
19
52D
52E
52C
52F
52B
50
63
POWER SOURCE
64
SENSOR DEVICE

FIG. 3

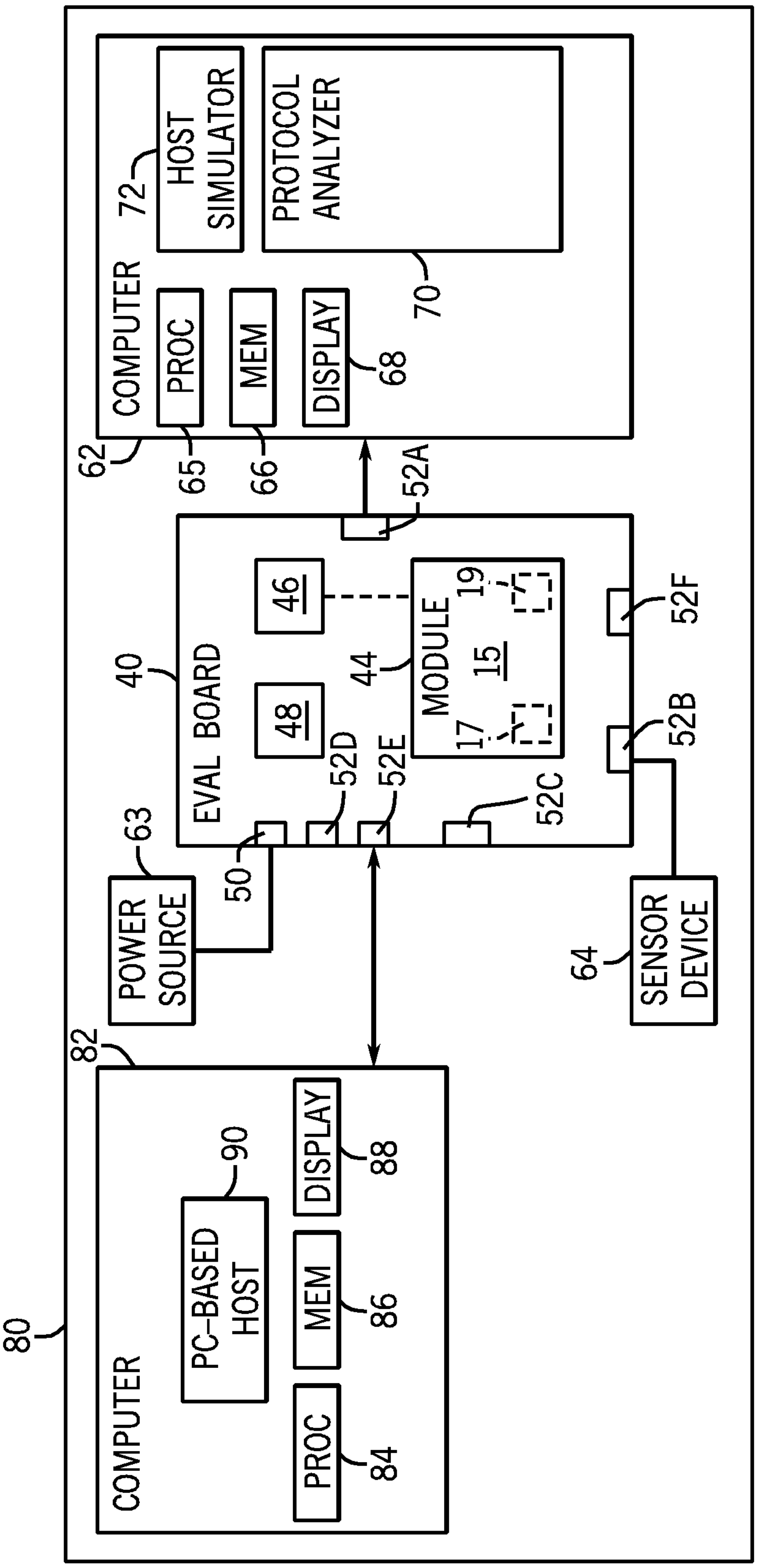

COMPUTER
PROC
MEM
DISPLAY
HOST SIMULATOR
PROTOCOL ANALYZER
72
70
68
62
65
66
52A
EVAL BOARD
40
46
48
MODULE
44
15
17
19
52D
52E
52C
52F
52B
50
63
POWER SOURCE
SENSOR DEVICE
64
82
COMPUTER
PC–BASED HOST
90
DISPLAY
88
MEM
86
PROC
84
80

FIG. 4

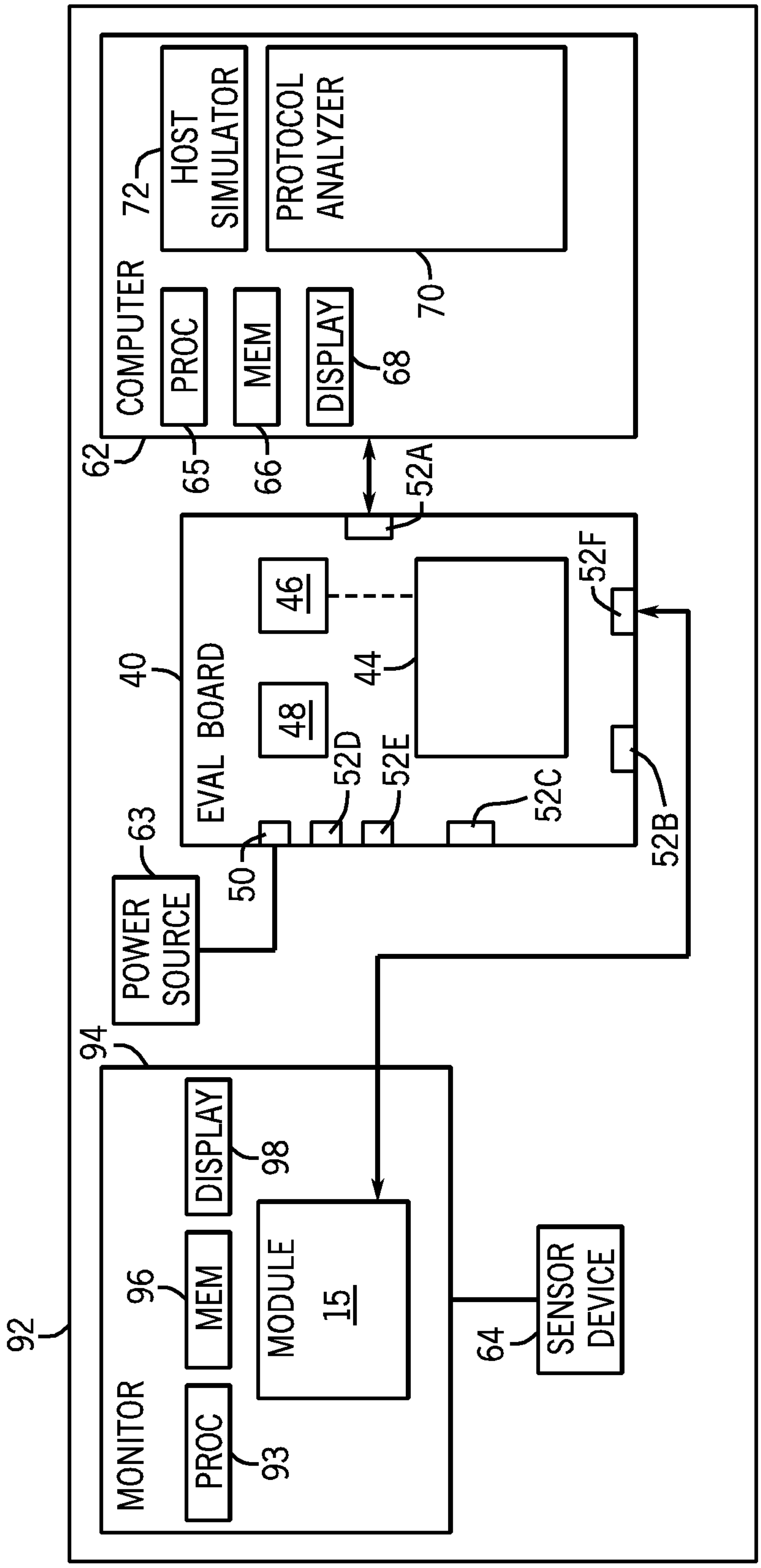

COMPUTER
PROC
MEM
DISPLAY
HOST SIMULATOR
PROTOCOL ANALYZER
62
65
66
68
70
72
52A
EVAL BOARD
40
46
48
44
52B
52C
52D
52E
52F
50
63
POWER SOURCE
94
MONITOR
PROC
MEM
DISPLAY
MODULE
15
93
96
98
92
64
SENSOR DEVICE

FIG. 5

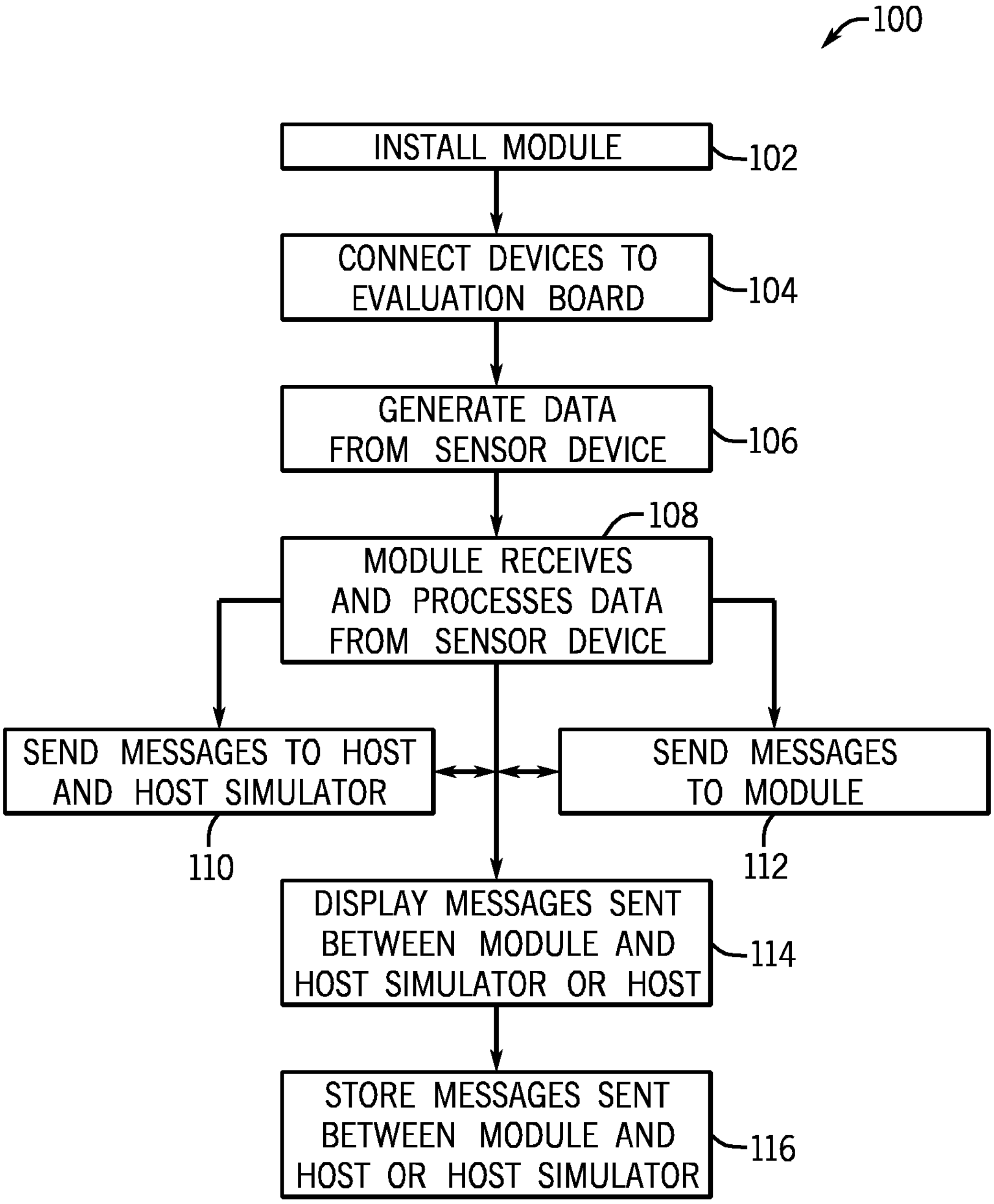

100
INSTALL MODULE
102
CONNECT DEVICES TO EVALUATION BOARD
104
GENERATE DATA FROM SENSOR DEVICE
106
108
MODULE RECEIVES AND PROCESSES DATA FROM SENSOR DEVICE
SEND MESSAGES TO HOST AND HOST SIMULATOR
110
SEND MESSAGES TO MODULE
112
DISPLAY MESSAGES SENT BETWEEN MODULE AND HOST SIMULATOR OR HOST
114
STORE MESSAGES SENT BETWEEN MODULE AND HOST OR HOST SIMULATOR
116

FIG. 6

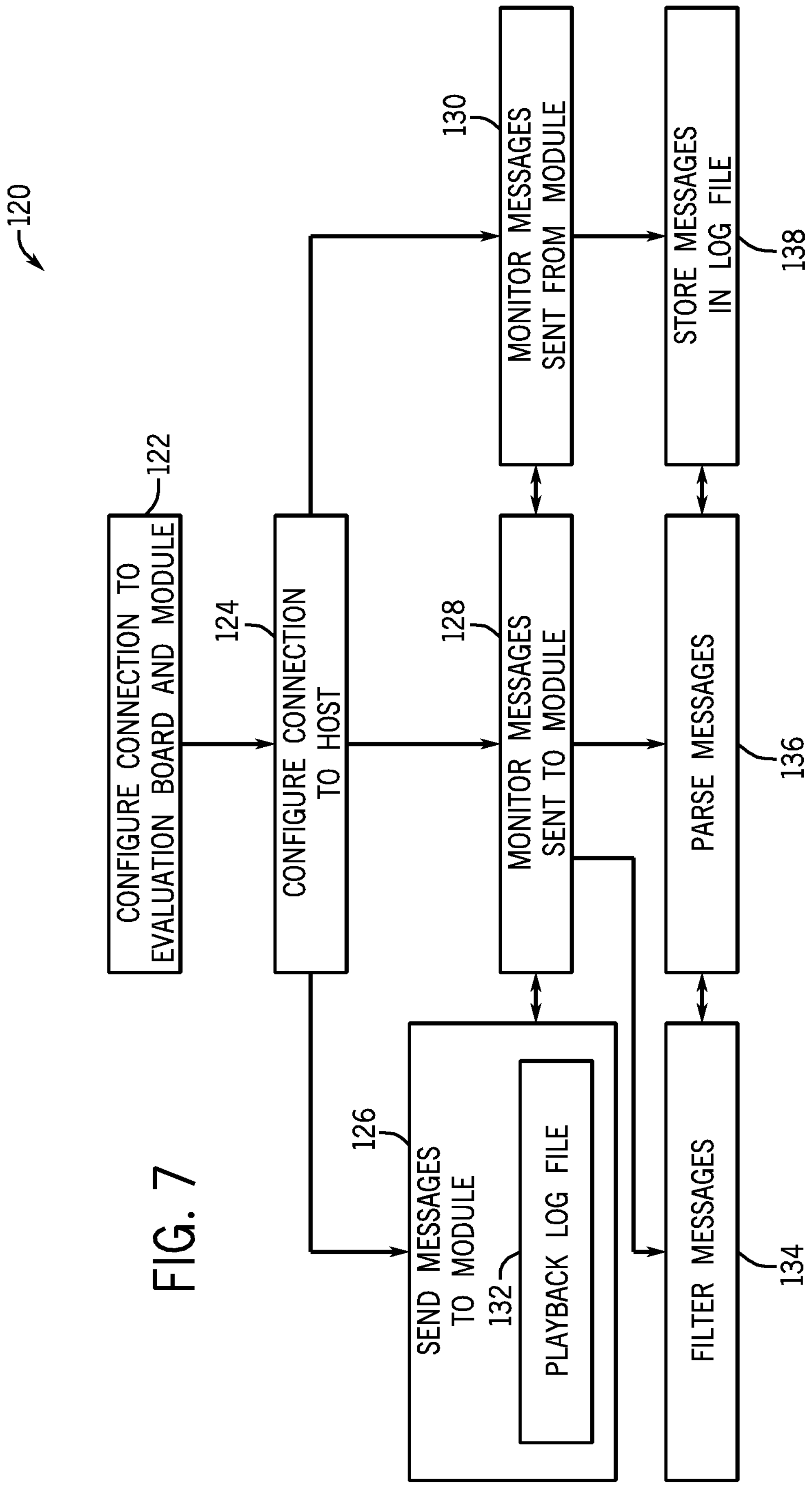

120
CONFIGURE CONNECTION TO EVALUATION BOARD AND MODULE
122
CONFIGURE CONNECTION TO HOST
124
MONITOR MESSAGES SENT TO MODULE
128
MONITOR MESSAGES SENT FROM MODULE
130
SEND MESSAGES TO MODULE
126
PLAYBACK LOG FILE
132
STORE MESSAGES IN LOG FILE
138
PARSE MESSAGES
136
FILTER MESSAGES
134

FIG. 7

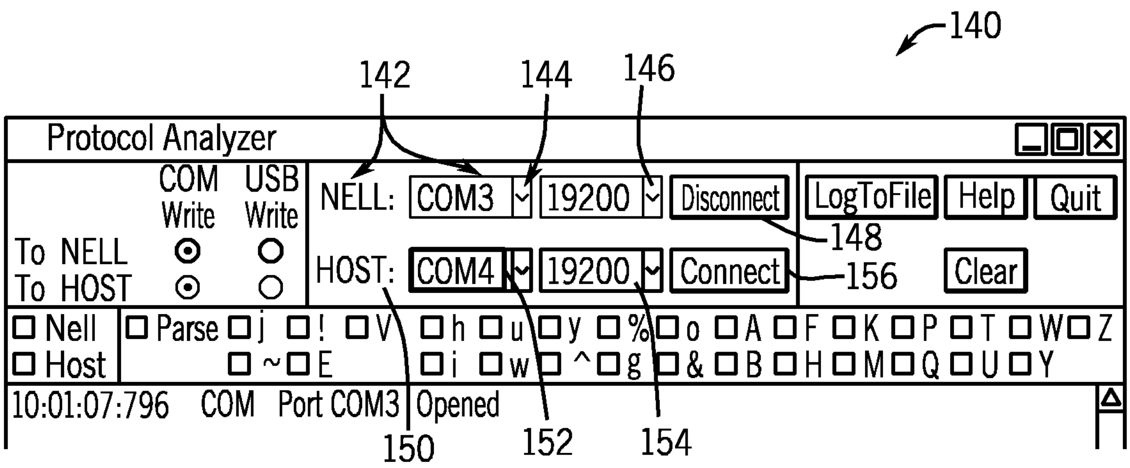

140
142
144
146
Protocol Analyzer
COM Write
USB Write
To NELL
To HOST
NELL: COM3 19200 Disconnect
HOST: COM4 19200 Connect
LogToFile Help Quit
Clear
148
156
Nell
Host
Parse j ! V h u y % o A F K P T W Z
~ E i w ^ g & B H M Q U Y
10:01:07:796 COM Port COM3 Opened
150
152
154

FIG. 8

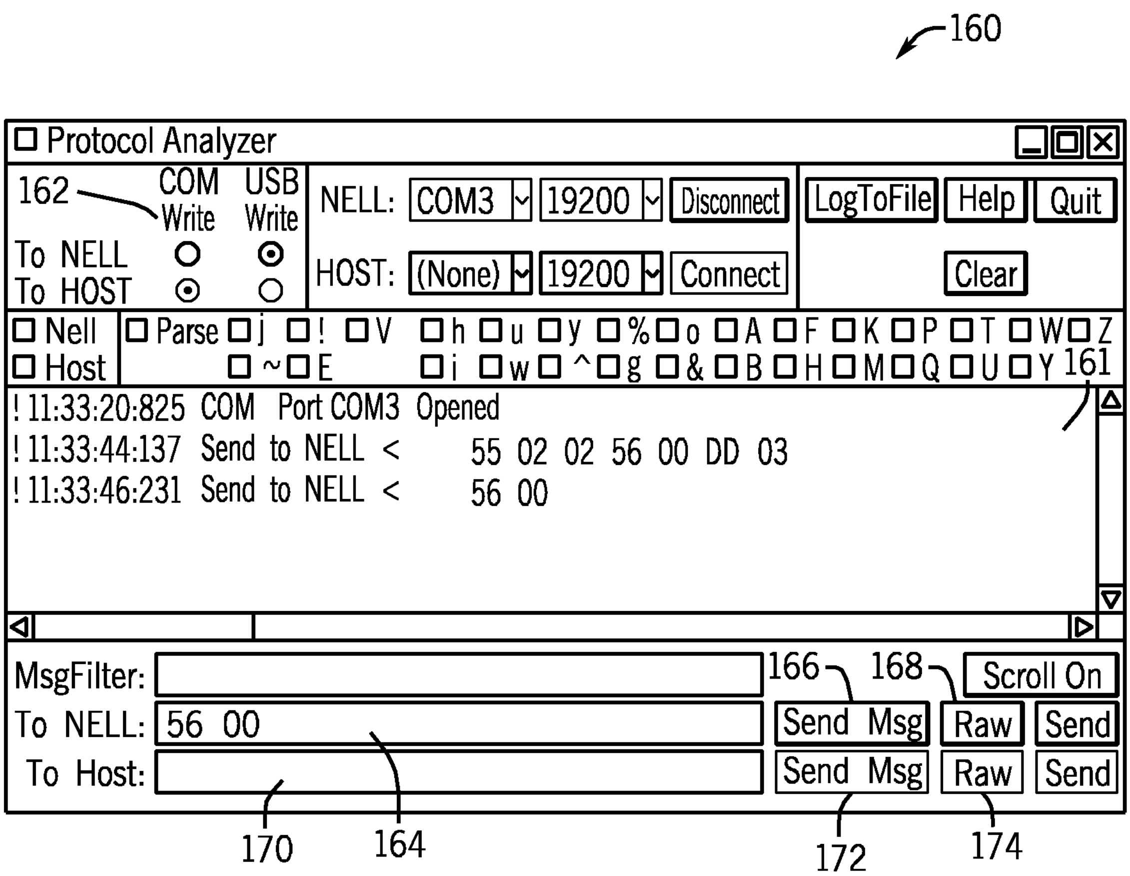
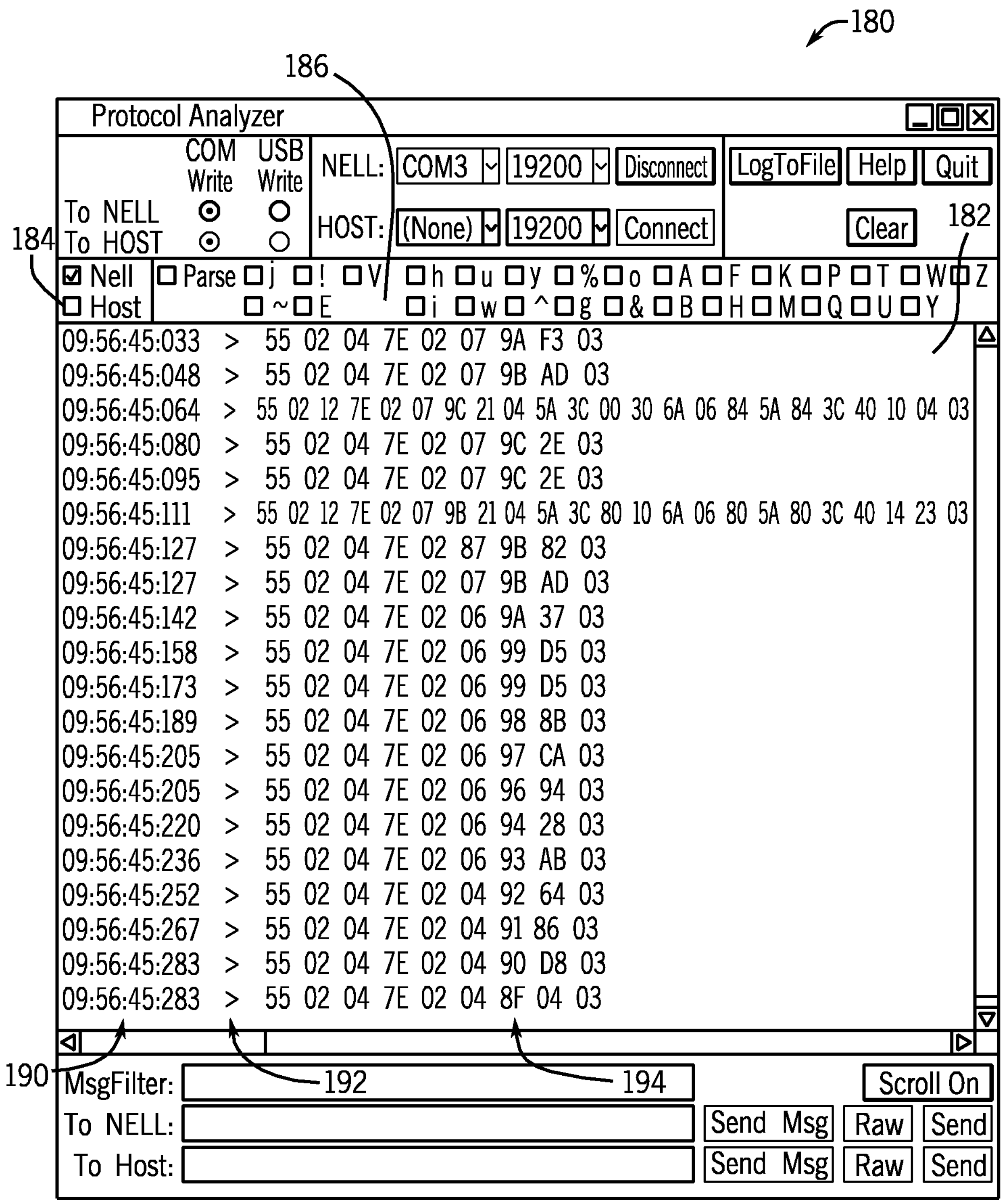

160
Protocol Analyzer
162
COM Write
USB Write
To NELL
To HOST
NELL: COM3 19200 Disconnect
HOST: (None) 19200 Connect
LogToFile Help Quit
Clear
Nell
Host
Parse j ! V h u y % o A F K P T W Z
~ E i w ^ g & B H M Q U Y
161
! 11:33:20:825 COM Port COM3 Opened
! 11:33:44:137 Send to NELL < 55 02 02 56 00 DD 03
! 11:33:46:231 Send to NELL < 56 00
MsgFilter:
To NELL: 56 00
To Host:
166
168
Scroll On
Send Msg Raw Send
Send Msg Raw Send
170
164
172
174

FIG. 9



180
186
Protocol Analyzer
COM Write
USB Write
To NELL
To HOST
NELL: COM3 19200 Disconnect
HOST: (None) 19200 Connect
LogToFile Help Quit
Clear
182
184
Nell
Host
Parse j ! V h u y % o A F K P T W Z
~ E i w ^ g & B H M Q U Y
09:56:45:033 > 55 02 04 7E 02 07 9A F3 03
09:56:45:048 > 55 02 04 7E 02 07 9B AD 03
09:56:45:064 > 55 02 12 7E 02 07 9C 21 04 5A 3C 00 30 6A 06 84 5A 84 3C 40 10 04 03
09:56:45:080 > 55 02 04 7E 02 07 9C 2E 03
09:56:45:095 > 55 02 04 7E 02 07 9C 2E 03
09:56:45:111 > 55 02 12 7E 02 07 9B 21 04 5A 3C 80 10 6A 06 80 5A 80 3C 40 14 23 03
09:56:45:127 > 55 02 04 7E 02 87 9B 82 03
09:56:45:127 > 55 02 04 7E 02 07 9B AD 03
09:56:45:142 > 55 02 04 7E 02 06 9A 37 03
09:56:45:158 > 55 02 04 7E 02 06 99 D5 03
09:56:45:173 > 55 02 04 7E 02 06 99 D5 03
09:56:45:189 > 55 02 04 7E 02 06 98 8B 03
09:56:45:205 > 55 02 04 7E 02 06 97 CA 03
09:56:45:205 > 55 02 04 7E 02 06 96 94 03
09:56:45:220 > 55 02 04 7E 02 06 94 28 03
09:56:45:236 > 55 02 04 7E 02 06 93 AB 03
09:56:45:252 > 55 02 04 7E 02 04 92 64 03
09:56:45:267 > 55 02 04 7E 02 04 91 86 03
09:56:45:283 > 55 02 04 7E 02 04 90 D8 03
09:56:45:283 > 55 02 04 7E 02 04 8F 04 03
190
192
194
MsgFilter:
Scroll On
To NELL: Send Msg Raw Send
To Host: Send Msg Raw Send

FIG. 10

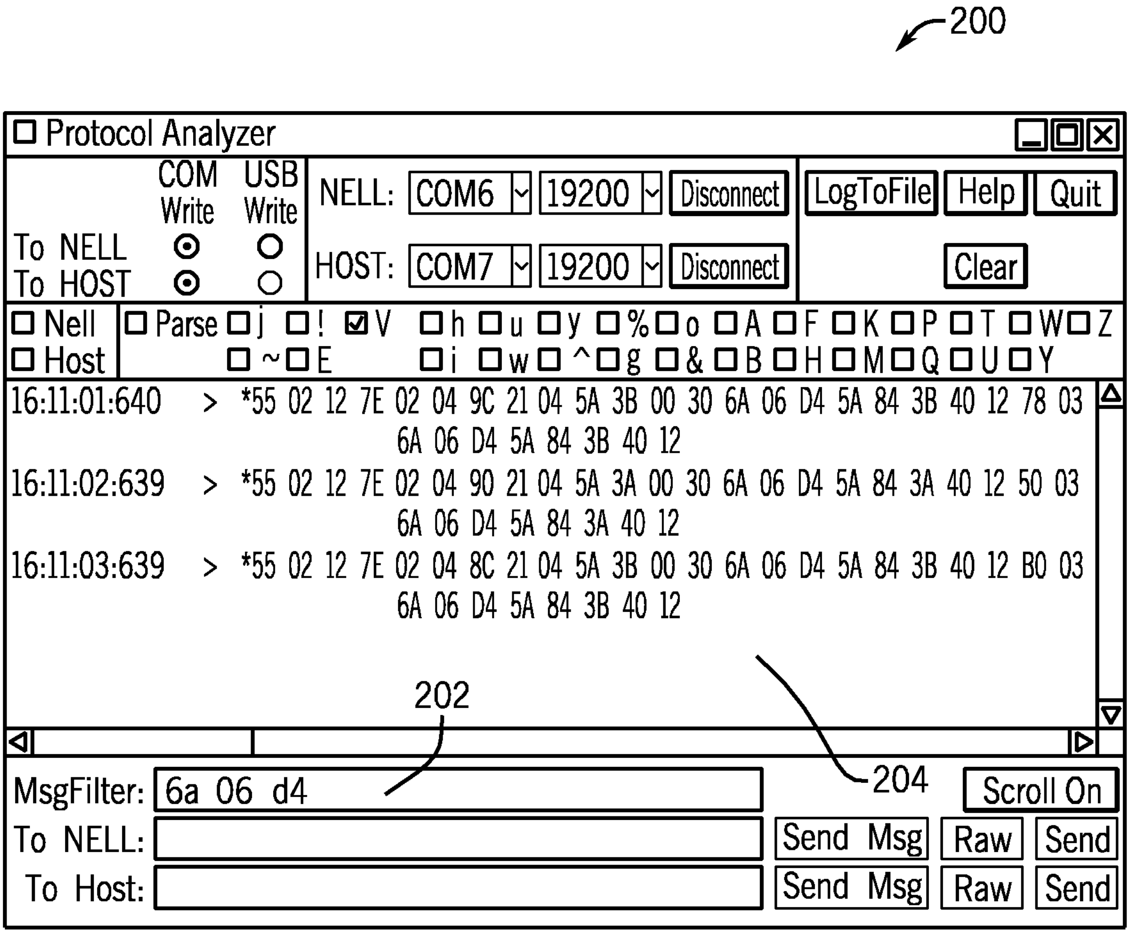

200
Protocol Analyzer
COM Write
USB Write
To NELL
To HOST
NELL: COM6 19200 Disconnect
HOST: COM7 19200 Disconnect
LogToFile
Help
Quit
Clear
Nell
Host
Parse j ! V h u y % o A F K P T W Z
~ E i w ^ g & B H M Q U Y
16:11:01:640 > *55 02 12 7E 02 04 9C 21 04 5A 3B 00 30 6A 06 D4 5A 84 3B 40 12 78 03
6A 06 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
202
204
MsgFilter: 6a 06 d4
Scroll On
To NELL:
Send Msg
Raw
Send
To Host:
Send Msg
Raw
Send

FIG. 11

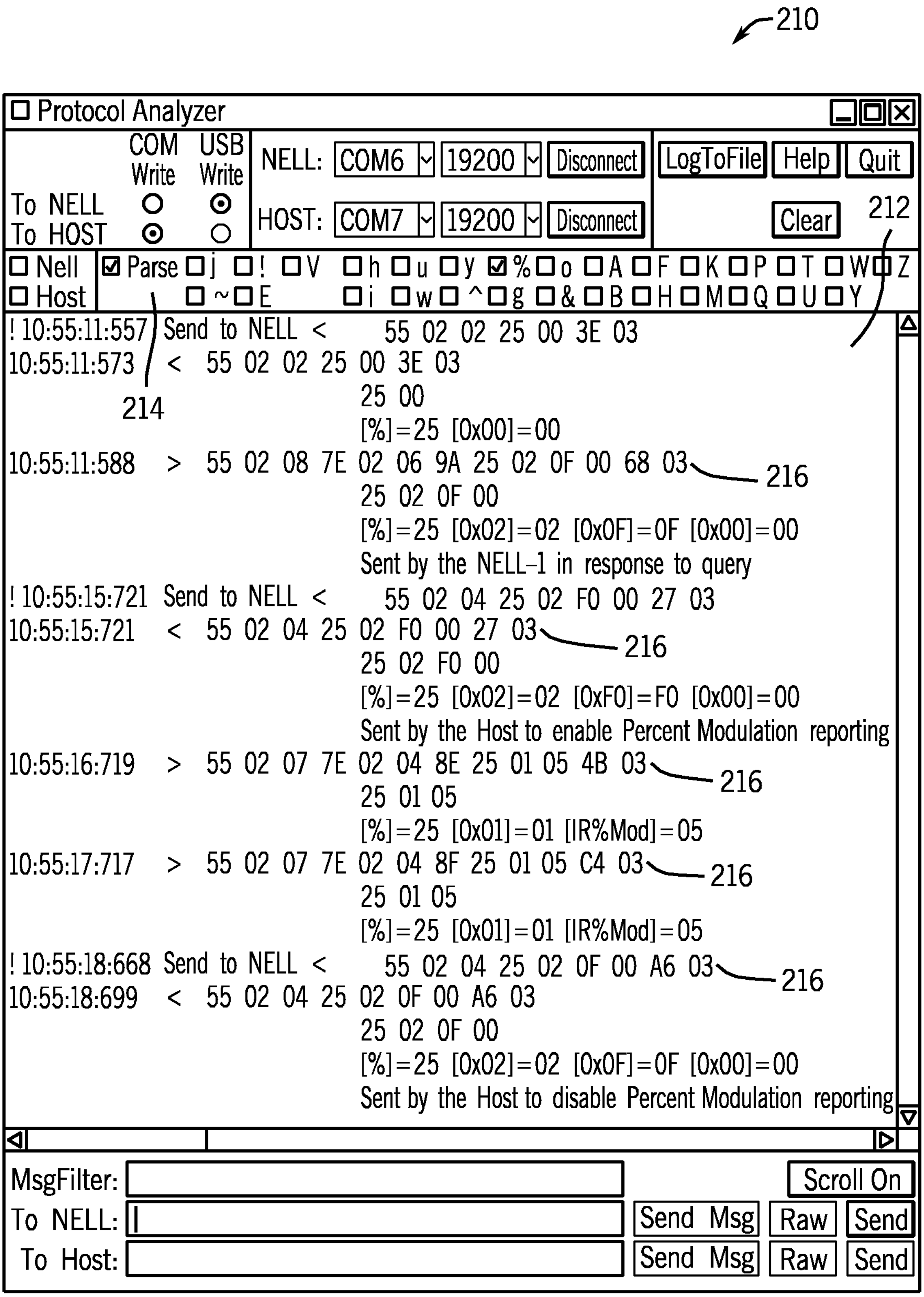

210
Protocol Analyzer
COM Write
USB Write
To NELL
To HOST
NELL: COM6 19200 Disconnect
HOST: COM7 19200 Disconnect
LogToFile Help Quit
Clear
212
Nell
Host
Parse j ! V h u y % o A F K P T W Z
~ E i w ^ g & B H M Q U Y
! 10:55:11:557 Send to NELL < 55 02 02 25 00 3E 03
10:55:11:573 < 55 02 02 25 00 3E 03
214
25 00
[%]=25 [0x00]=00
10:55:11:588 > 55 02 08 7E 02 06 9A 25 02 0F 00 68 03
216
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
216
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
216
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
216
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
216
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:
Scroll On
To NELL:
Send Msg Raw Send
To Host:
Send Msg Raw Send

FIG. 12

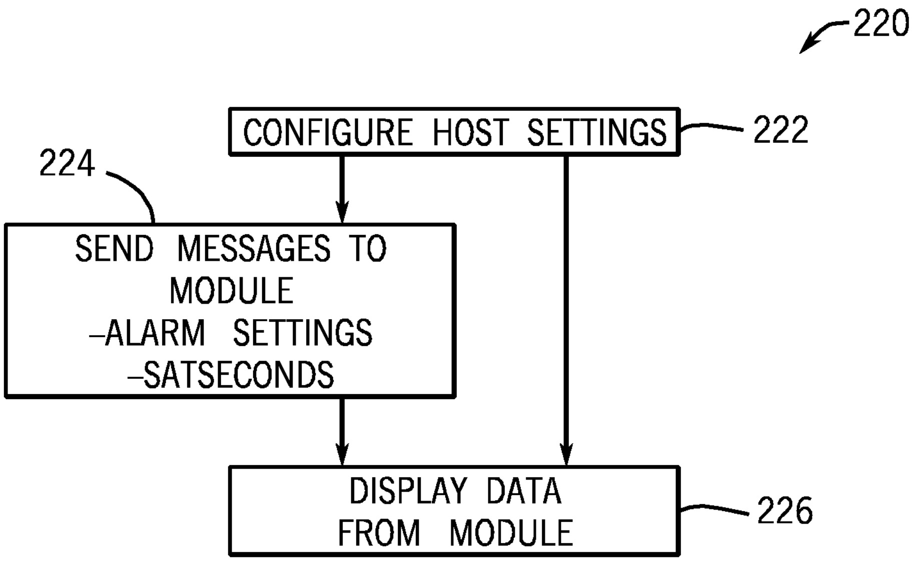

220
CONFIGURE HOST SETTINGS
222
224
SEND MESSAGES TO MODULE
-ALARM SETTINGS
-SATSECONDS
DISPLAY DATA FROM MODULE
226

FIG. 13

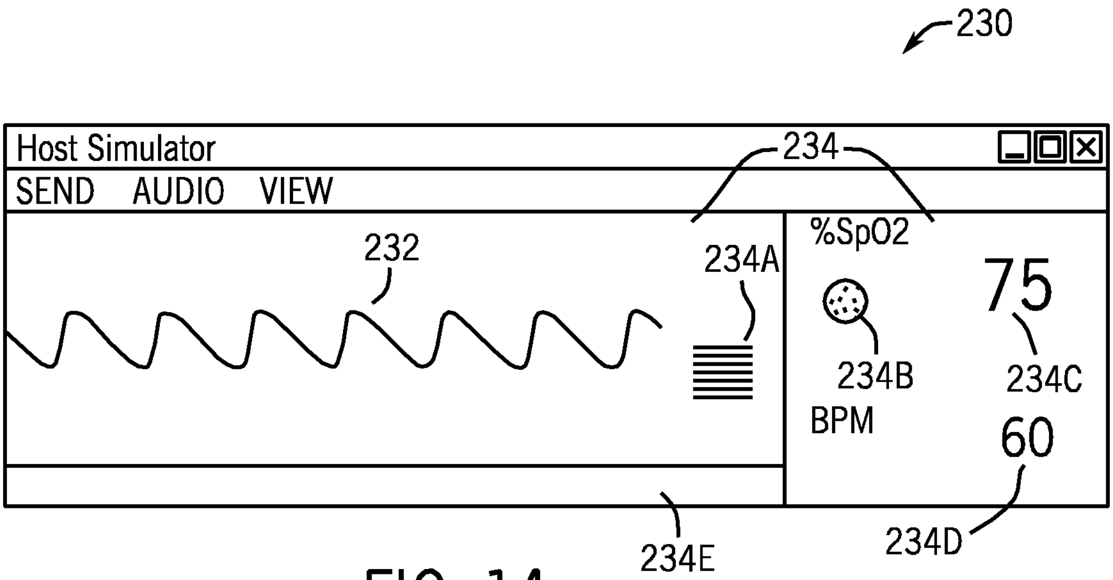

230
Host Simulator
SEND AUDIO VIEW
234
232
234A
%SpO2
75
234B
234C
BPM
60
234E
234D

FIG. 14

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2010/042621

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.
Y	US 5 375 604 A (KELLY CLIFFORD M [US] ET AL) 27 December 1994 (1994-12-27) the whole document -----	1-20
Y	Anonymous: "Logic analyzer", Wikipedia, the free encycloedia , 8 September 2009 (2009-09-08), XP002608989, Retrieved from the Internet: URL:http://en.wikipedia.org/w/index.php?title=Logic_analyzer&oldid=312680596 [retrieved on 2009-09-08] the whole document -----	1-20
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[X] Further documents are listed in the continuation of Box C.

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INTERNATIONAL SEARCH REPORT

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

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