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(54) **INTERFACE DEVICE FOR COMMUNICATION BETWEEN A MEDICAL DEVICE AND A COMPUTER**

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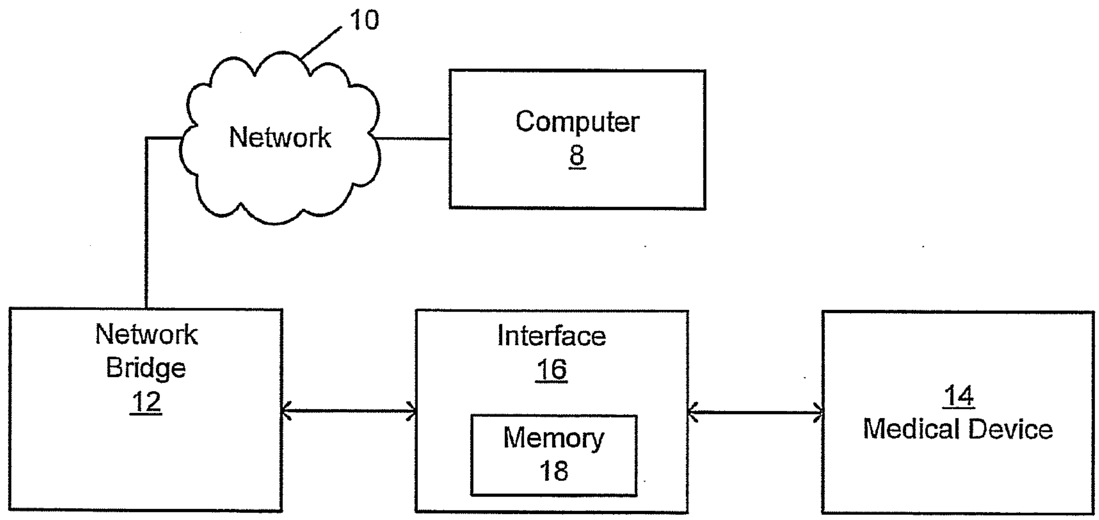
(52) **U.S. Cl.** **709/204**

(57) **ABSTRACT**

The present invention relates to an interface device and a method for communication between a medical device and a computer system. In some embodiments, the interface device comprises a conversion device and/or a processor-transceiver and a memory in electrical communication with the conversion device, wherein the memory contains data to instruct the conversion device and/or the processor transceiver how to communicate with the medical device.



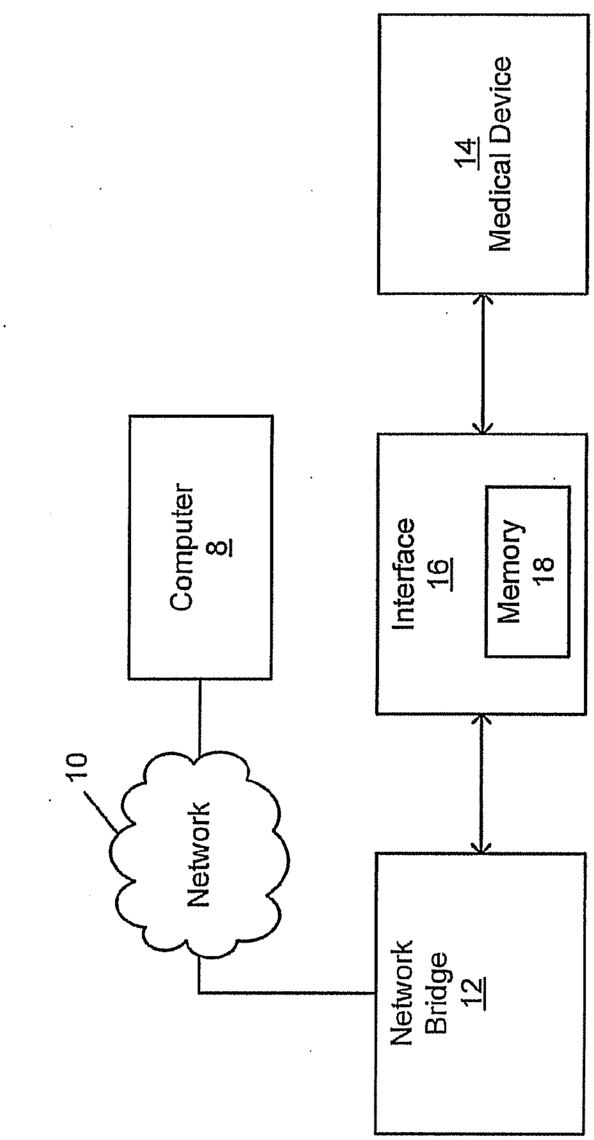

14
Medical Device
Computer
8
Interface
16
Memory
18
10
Network
Network
Bridge
12

FIG. 1

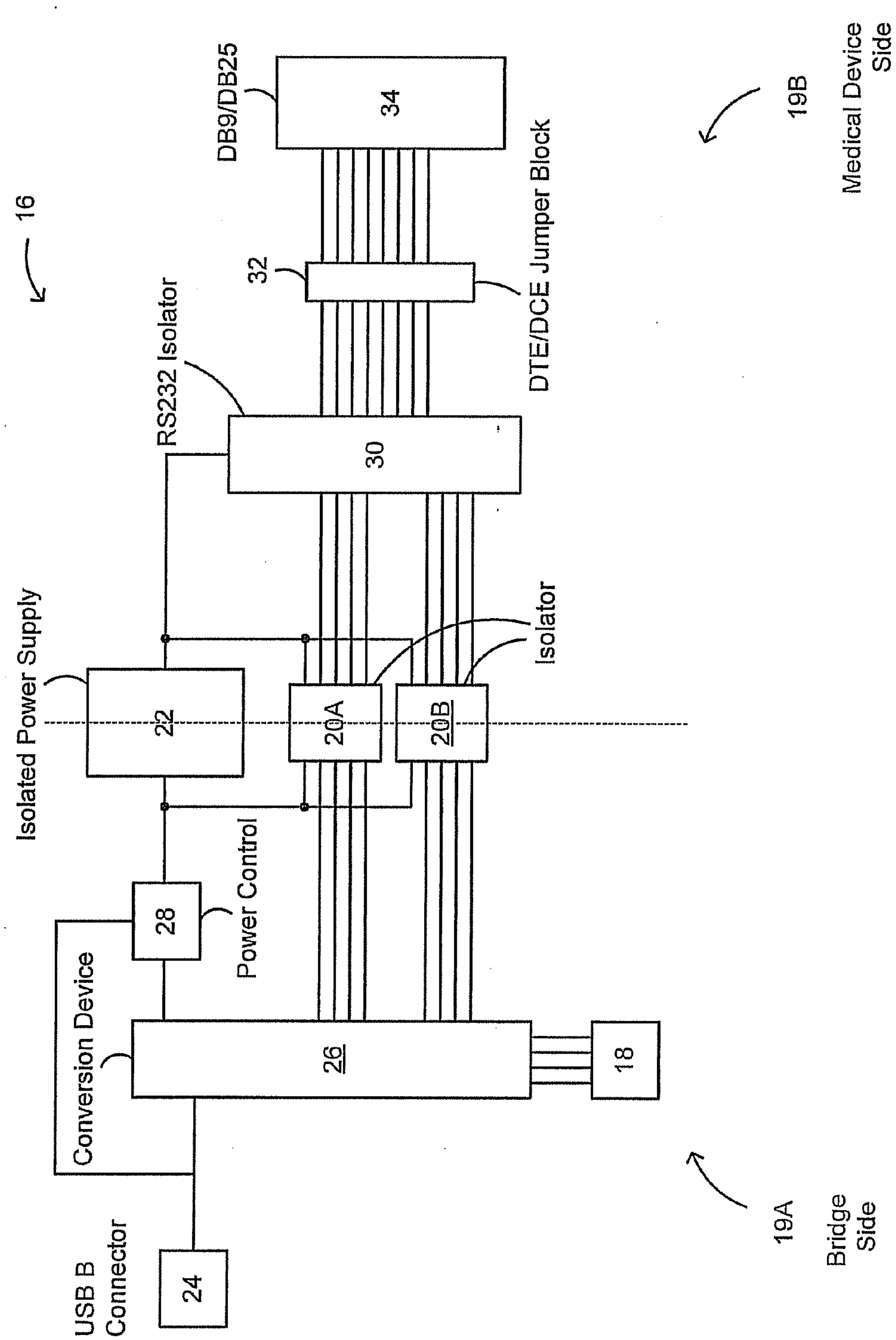

16
DB9/DB25
34
19B
Medical Device Side
32
DTE/DCE Jumper Block
RS232 Isolator
30
Isolated Power Supply
22
20A
20B
Isolator
Isolator
Power Control
28
Conversion Device
26
18
USB B Connector
24
19A
Bridge Side

FIG. 2

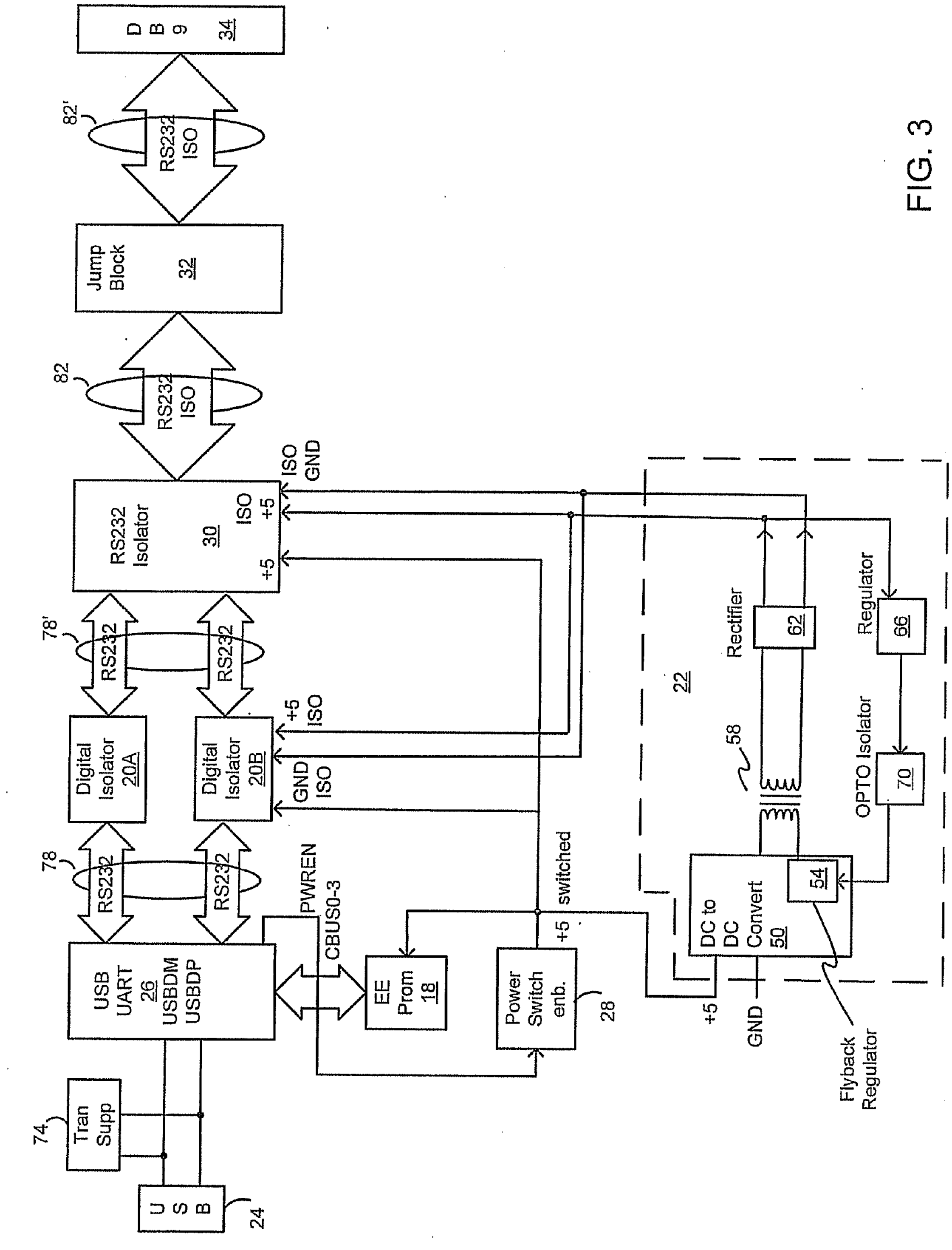

DB9
34
82'
RS232 ISO
Jump Block
32
82
RS232 ISO
ISO GND
RS232 Isolator
30
ISO +5
+5
78'
RS232
RS232
Digital Isolator 20A
Digital Isolator 20B
+5 ISO
GND ISO
78
RS232
RS232
PWREN
CBUS0-3
switched
+5
USB UART 26 USBDM USBDP
EE Prom 18
Power Switch enb.
28
Tran Supp
74
USB
24
22
Rectifier
62
Regulator
66
58
OPTO Isolator
70
DC to DC Convert 50
54
+5
GND
Flyback Regulator

FIG. 3

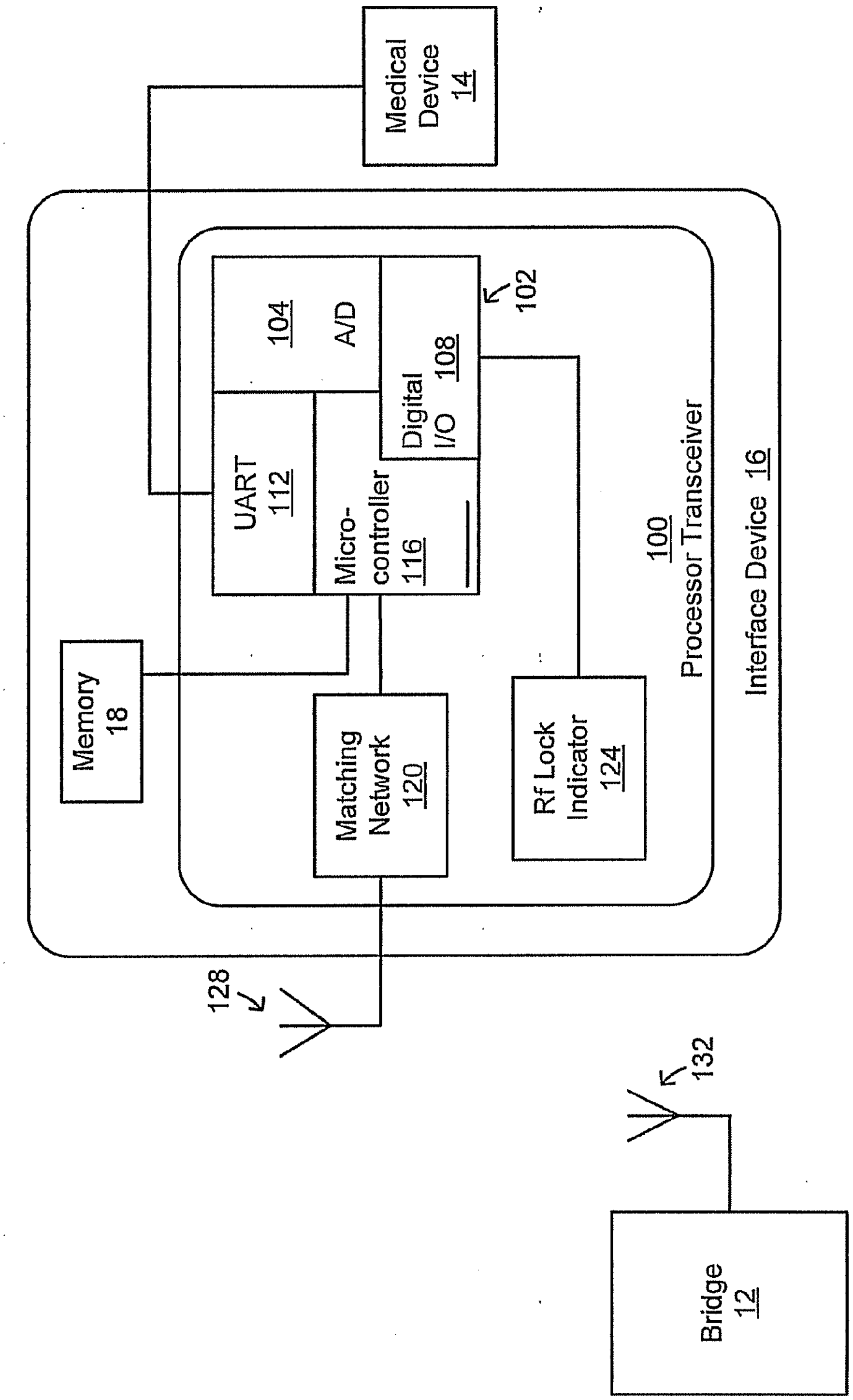

Medical Device 14
104
A/D
Digital I/O 108
102
UART 112
Micro-controller 116
Memory 18
Matching Network 120
Rf Lock Indicator 124
100 Processor Transceiver
Interface Device 16
128
132
Bridge 12

FIG. 4

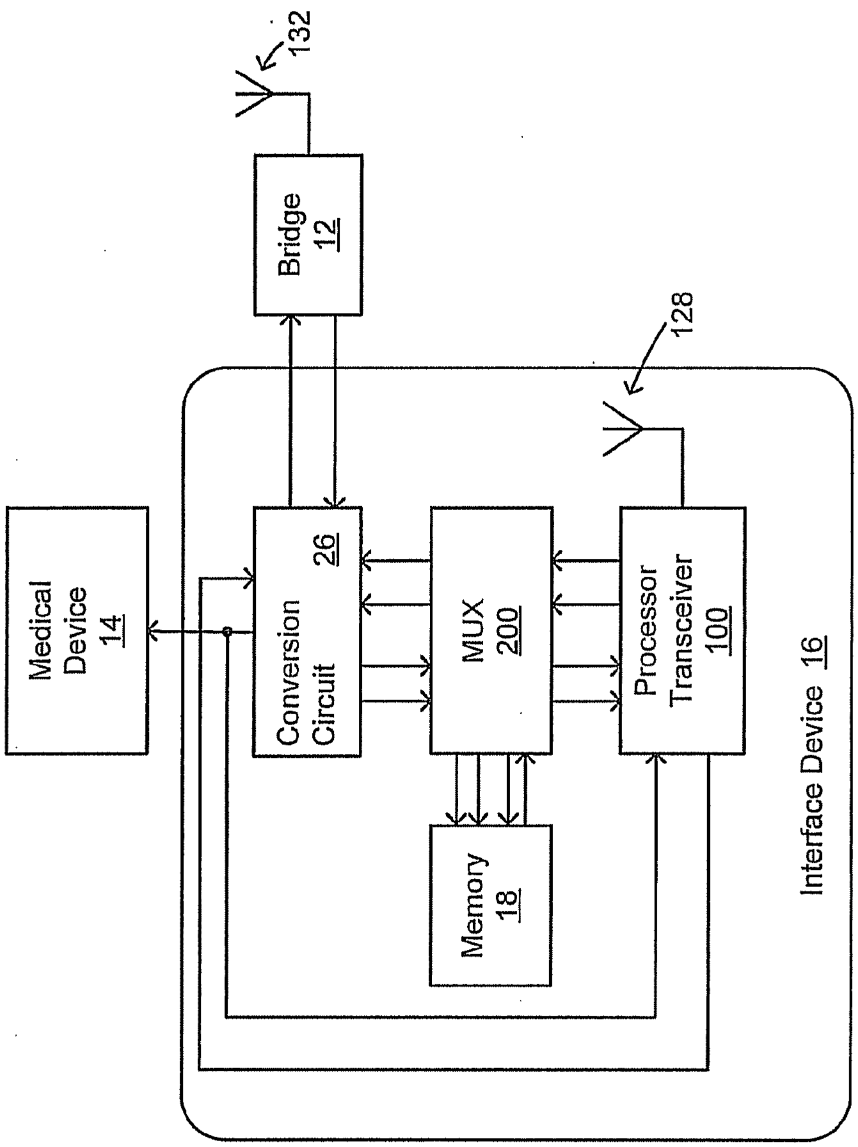

132
Bridge
12
128
Medical
Device
14
Conversion
Circuit
26
MUX
200
Processor
Transceiver
100
Memory
18
Interface Device 16

FIG. 5

INTERFACE DEVICE FOR COMMUNICATION BETWEEN A MEDICAL DEVICE AND A COMPUTER

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to and the benefit of U.S. Patent Application No. 61/148,259, filed Jan. 29, 2009, the entire disclosure of which is incorporated by reference herein.

FIELD OF THE INVENTION

[0002] The present invention relates to an interface device for communication between a medical device and a network.

BACKGROUND OF THE INVENTION

[0003] In a hospital, patients' vital signs are monitored by numerous electronic devices. Each one of these devices produces its own set of data with its own format that must be compiled and analyzed. In order to record all of this vital information, the electronic devices need to communicate with a computer system. However, the computer system may not be able to communicate with the various electronic devices because the computer's communication protocol may differ from that of the electronic device.

[0004] Therefore, a need exists for a system where a medical device can communicate with a computer system for recording and compiling patient information.

SUMMARY OF THE INVENTION

[0005] In satisfaction of these needs and others, the present invention relates to an interface device to facilitate communication between a medical device and a bridge. In one aspect, the present invention relates to the interface device comprising an interface device and a memory in electrical communication with the interface device, wherein the memory contains data to instruct the interface device how to communicate with the medical device. In other embodiments, the interface device can include an RS232 transceiver, a solid state isolator, and/or an isolated power supply having a power control circuit, each in electrical communication with the interface device.

[0006] Another aspect of the present invention relates to a system for communication between a computer and a medical device. In one embodiment, the system comprises a bridge, a USB/RS232 circuit in electrical communication with the bridge, a memory in electrical communication with the USB/RS232 circuit, and the medical device in electrical communication with the USB/RS232 circuit, wherein the memory contains data to instruct the USB/RS232 circuit on how to communicate with the medical device.

[0007] Another aspect of the present invention relates to a method of communicating between a medical device and a bridge, comprising the steps of storing communication data to identify and communicate with the medical device, receiving medical device data from the medical device, and using the communication data to communicate with the medical device and to convert medical device data from the medical device to permit the medical device to communicate with the bridge.

[0008] Another aspect of the present invention relates to a wireless interface device for communication between an medical device and a bridge including a processor-transceiver, a memory in electrical communication with the processor-transceiver, and a wireless transmitter in electrical communication with the processor-transceiver and in wireless communication with the bridge, wherein the memory contains communication data to instruct the processor-transceiver how to communicate with the medical device. The processor-transceiver can include a micro-controller.

[0009] Another aspect of the present invention relates to a system for communication between a computer and an medical device including a bridge, a processor-transceiver in wireless communication with the bridge, a memory in electrical communication with the processor-transceiver, and the medical device in electrical communication with the processor-transceiver, wherein the memory contains communication data to instruct the processor-transceiver on how to communicate with the medical device.

[0010] Another aspect of the present invention relates to a method of communicating between an medical device and a bridge including the steps of: storing communication data to communicate with the medical device, receiving medical device data from the medical device, using the communication data to convert medical device data from the medical device to permit the medical device to communicate with the bridge, and transmitting the communication data wirelessly to the bridge.

[0011] Another aspect of the present invention relates to a system for communication between a medical device and a bridge including a medical device, a conversion circuit in electrical communication with the medical device, a processor-transceiver in electrical communication with the medical device, an antenna in electrical communication with the processor-transceiver, a multiplexer in electrical communication with both the conversion circuit and the processor-transceiver, and a memory in electrical communication with the multiplexer, wherein the multiplexer permits either the conversion circuit or the processor-transceiver to communicate with the memory, and wherein the memory contains communication data to instruct the processor-transceiver on how to communicate with the medical device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] These embodiments and other aspects of this invention will be readily apparent from the description below and the appended drawings, which are meant to illustrate and not to limit the invention, and in which:

[0013] FIG. **1** is a block diagram illustrating a system for connecting to bridge and an medical device through an interface device, according to an embodiment of the present invention;

[0014] FIG. **2** is a block diagram of an embodiment of the interface device according to the present invention;

[0015] FIG. **3** is a more detailed diagram of an embodiment of the invention in FIG. **2**;

[0016] FIG. **4** is a block diagram of a system for connecting a bridge and an medical device through an interface device, according to an embodiment of the present invention; and

[0017] FIG. **5** is a block diagram of a system for connecting a bridge and a medical device.

DESCRIPTION

[0018] The present invention will be more completely understood through the following description, which should be read in conjunction with the attached drawings. In this description, like numbers refer to similar elements within various embodiments of the present invention. Within this description, the claimed invention will be explained with respect to embodiments. However, the skilled artisan will readily appreciate that the methods and systems described herein are merely exemplary and that variations can be made without departing from the spirit and scope of the invention.

[0019] In general, and referring to FIG. **1**, the present invention relates to an interface device **16** to facilitate communication between a medical device **14** and a computer system. As shown in FIG. **1** such a system includes a computer **8** in communication with a network **10**. Also in communication with the network **10** are one or more bridges **12** that permit medical devices **14** to communicate with the network **10**. Typical bridges **12** have one or more uniform input ports that are frequently Universal Serial Bus ports (USB ports) and an output port (for example an ethernet port) which is configured to communicate with the network **10** to which the bridge **12** is attached. Unfortunately, most medical devices **14** have output ports which are RS232 compatible serial ports and which produce only RS232 compatible output signals. The medical device can be pulse oximeters, ventilators, EKG devices, and various other health-related monitoring devices.

[0020] These medical devices **14** use data transmission protocols which are specific to the individual medical device **14**. As a result, there is both an electrical and protocol mismatch between the medical device **14** and the bridge **12**. To best permit the medical device **14** to communicate with the bridge **12** without requiring the bridge **12** to accept and recognize all forms of communication signals and protocols, an interface device **16** is placed between the medical device **14** and the bridge **12**.

[0021] This interface device **16** is then programmed to communicate with each medical device **14** to which it is connected. The interface device **16**, sometimes referred to as a dongle, is a small hardware device that has a proper electrical or wireless port (e.g. RS232 serial port) to connect to the medical device **14** and a second port that is the correct electrical port (e.g. USB port) to communicate with the bridge **12**.

[0022] In more detail and as shown in FIG. **2**, the interface device **16** may be considered to have a bridge side **19**A and a medical device side **19**B which are connected together through one or more isolators **20**A, **20**B (generally **20**) and a conversion circuit **26**. The isolators are electrical safety devices to provide electrical isolation between the bridge and the medical device, (and hence the patient to which the device **14** is connected). In various embodiments, the isolators **20** are optical isolators or galvimetric isolators.

[0023] A conversion circuit **26** converts the data received from the medical device **14** to data usable by the bridge **12** and sends that data to the bridge **12** through a connector **24**, and vice versa. In one embodiment, the conversion circuit **26** is a USB/RS232 circuit, which converts the RS232 serial signals from the medical device **14** to USB signals usable by the bridge **12** and USB signals from the bridge **12** to RS232 signals usable by the medical device **14**

[0024] In general, signals passing from the medical device **14** pass through the isolators **20**A and **20**B, before entering the conversion circuit **26** for conversion to USB signals. Similarly, signals entering the conversion circuit **26** from the bridge **12** pass through the isolators **20**A, **20**B before passing to the medical device **14**. However, for some electronic devices, the medical device data cannot be converted to bridge data that the bridge **12** can process unless the data is recognized and converted by the conversion circuit **26**. Instructions on how to convert and modify the medical device data (such as RS232 serial data) into bridge data (such as USB data) is stored in the memory **18** which is connected to the conversion circuit device **26** and is provided to the conversion circuit **26** when the interface **16** is initially powered on.

[0025] The memory **18** in one embodiment is an Electrically Erasable Programmable Read-Only Memory ("EEPROM"). The EEPROM can have a memory of from 256 bytes to 512 bytes. The memory **18** in one embodiment typically is contained within the interface device **16**. The memory **18** is programmed to identify and communicate with various electronic devices. For example, the memory **18** of the interface device **16** is generally programmed prior to its connection with the intended medical device, for example, a ventilator. When the interface device **16** is the connected between the ventilator and to the bridge **12**, the memory **18** of the interface device **16** is already programmed to permit the bridge **12** to communicate with the ventilator.

[0026] The interface **16** also includes an isolated power supply **22** and power controller **28**. The isolated power supply **22** powers the components of the interface device **16** and is also constructed to electrically isolate the bridge **12** from the medical device **14**. In one embodiment, the isolated power supply **22** includes a 4,000 volt, pulse-width-modulated power supply constructed with a triply insulated transformer. The power controller **28** controls the power to the USB/RS232 circuit and the other components of the interface **16**. The isolated power supply **22** is discussed in more detail below.

[0027] In one embodiment, an RS232 transceiver **30**, a RS232 DTE/DCE jumper block **32** and a DB9/DB25 connector are located between the medical device **14** and the isolators **20**A, **20**B. The RS232 transceiver is a standard RS232 transceiver, with ports in communication with the isolators **20**A and **20**B, and ports in communication with the DTE/DCE jumper block **32**. The data terminal equipment/data circuit-terminating ("DTE/DCE") jumper block **32** enables the transmission and reception of signals to and from different pins in the DB9/DB25 connector **34**.

[0028] In operation, the first step is the storing in the memory **18** of device communication data that instructs the conversion circuit **26** how to communicate with the medical device **14**. Typically, the communication data is stored on the interface device **16** prior to the interface device **16** being attached to the medical device **14** or bridge **12**. For example, a hospital technician identifies that an interface device **16** will be connected to a ventilator and programs the device communication data into the memory **18** of the interface device **16**. The data and protocol enables the interface device **16** to convert the ventilator data into a form that is readable by the bridge **12** and the computer system **8**.

[0029] Once the interface device **16** has the necessary communication data stored in its memory to permit the bridge **12** to communicate with the medical device **14**, the interface device **16** begins receiving device data from the medical device **14**. Once the interface device **16** starts receiving the medical device data, the conversion circuit **26** of the interface device **16** begins using the stored data and protocol to convert the medical device data received from the medical device **14** to permit the medical device **14** to communicate with the bridge **12**.

[0030] Referring now to FIG. **3**, a more detailed block diagram of the embodiment of an embodiment of the invention shown in FIG. **2** is shown. An important feature of the interface device **16** is the electrical isolation it provides between the bridge **12** and the medical device **14**. As shown in FIG. **3**, one portion of this electrical isolation is provided by the isolated power supply **22**. The isolated power supply **22** includes a DC to DC converter **50** which uses a flyback regulator **54** to produce a pulsed DC voltage from a static 5 volt DC source. In one embodiment, the flyback regulator is a National Semiconductor LM2587 (National Semiconductor, Santa Clara, Calif.). This pulsed DC voltage causes a pulsed current to pass through isolation transformer **58** before being rectified by a rectifier circuit **62** to 5 volts. The isolation transformer **58** is wound with triply insulated wire to avoid insulation breakdown. The output of the rectifier circuit **62** is sampled by a regulator **66** whose output controls the flyback regulator **54** through an opto-isolator **70**. In this way the voltage output from rectifier circuit **62** is isolated and regulated to 5 volts. In one embodiment, the regulator **66** is a National Semiconductor LM3411 (National Semiconductor, Santa Clara, Calif.) and the opto-isolator is an Agilent CNY17 (Agilent Technologies, Santa Clara, Calif.). The rectifier **62** in one embodiment is a discrete component half wave rectifier which is filtered to static DC. In one embodiment, the DC to DC converter is a discrete component converter. The regulated isolated 5 volts is then supplied to the components on the isolated side (medical device side) of the interface device **16**.

[0031] As shown in FIG. **3**, the USB connector **24** is connected to a USB UART (universal asynchronous receiver transmitter) conversion circuit **26** by way the input ports USBDM and USBDP. In one embodiment, the conversion circuit **26** is an FTDI FT232R USB UART integrated circuit (Future Technology Devices International Ltd, Glasgow, Scotland, United Kingdom). A transient suppressor **74** is connected across the USB ports to provide noise transient protection. In one embodiment, the suppressor **74** is a TI SN65220 universal serial bus port transient suppressor (Texas Instruments, Dallas, Tex.). The output ports **78** of the interface device **26** convey various signals to support an RS232 communication protocol. One output line of the interface device **26** is a power enable pin which is used to control a power switch **28**. In one embodiment, the power switch **28** is a MIC2026 power distribution switch (Micrel Inc, San Jose, Calif.)

[0032] The output of the power switch **28** is a 5 volt switched source which connects to the memory **18**, the RS232 isolator **30** and the digital isolator **20**A, **20**B (only one shown connected for clarity) and the DC to DC converter **50**. In one embodiment, the memory is an EEPROM AT93C56 (Atmel Corporation, San Jose, Calif.). The memory is connected to the switch **28** output by the Vcc pin of the memory **18**. The output of the memory **18** CBUS**0**-CBUS**3** is connected to pins GPI**0**-GPI**3** of the interface device **26**. In operation, until the USB UART **26** is fully enabled, the switch **28** prevents any of the powered components to which the switch **28** is connected from being fully powered.

[0033] The RS232 lines **78** are connected to the RS232 isolator **30** through the digital isolators **20**A and **20**B. In one embodiment, the digital isolators **30** are ADμ1M2400 digital isolators (Analog Devices, Norwood, Mass.). These digital isolators electrically isolate the signals passing between the interface conversion circuit **26** and the RS232 isolator **30**. In one embodiment, the RS232 isolator is an ADM213E 15 kV ESD-Protected RS-232 Line Driver/Receiver (Analog Devices, Norwood, Mass.). The RS232 isolator **30** further isolates the RS232 signals to form isolated RS232 signals **82** which are then input to the jumper block **32**. The jumper block **32** connects the RS232 isolator **30** to the DB9 connector **34** and allows the correct signals to be jumpered to the correct pins of the RS232 connector **34**. In this way, both DB25 and DB29 connectors can be used with the device.

[0034] In another embodiment, as shown in FIG. **4**, the medical device **14** communicates with the bridge **12** wirelessly through a wireless interface device **16** having an antenna **128** and a processor-transceiver **100**. As noted above, the bridge **12** then communicates through the network to the computer. In general, serial data signals containing medical device data passing from the medical device **14** enter the processor-transceiver **100** for conversion to USB signals. However, as noted above, for some medical devices, the medical device data cannot be converted to bridge data that the bridge **12** can process unless the data is recognized and converted by the processor-transceiver **100**. Instructions on how to convert and modify the medical device data (such as RS232 serial data) into bridge data (such as USB data) are stored in the memory **18**, which is electrically connected to the processor-transceiver **100**. The instructions are provided to the processor-transceiver **100** when the interface device **16** is initially powered on. Then the interface device **16**, shown in FIG. **4**, wirelessly transmits the data to the bridge **12**.

[0035] In the embodiment shown in FIG. **4**, the processor-transceiver **100** contains an nRF24E1 processor **102** made by Nordic Semiconductor ASA (Tiller, Norway). The processor **102** has a 2.4 GHz RF transceiver with an embedded 8051 micro-controller **116**, a multi-channel 12 bit A/D converter **104**, a universal asynchronous receiver/transmitter ("UART") **112**, and a digital I/O port **108**. The processor **102** is a clock based processor, which operates at 1.9 volts, and has no external bus. The medical device **14** passes the data to the processor **102** as serial data through the UART **112**.

[0036] The Nordic nRF24E1 processor **102** provides the encoded output signal to the transceiver portion for transmission by the Nordic nRF24E1 processor **102** to the antenna **128** through the matching network **120**. The matching network **120** to impedance matches the antenna **128**. The transceiver portion of the processor **102** can be set to operate on any one of 80 frequencies in the 2.4 GHz ISM band. Finally, the integral digital I/O portion **108** produces an output signal to the RF lock indicator **124** that the RF frequency has been detected and is locked onto.

[0037] In operation the first step is the storing in the memory **18** of device communication data that instructs the processor-transceiver **100** how to communicate with the medical device **14**. Typically, the communication data is stored on the interface device **16** prior to the interface device **16** being attached to the medical device **14**. For example, a hospital technician identifies that an interface device **16** will be connected to a ventilator and programs the device communication data into the memory **18** of the interface device **16**. For example, the data and protocol enables the interface device **16** to convert the ventilator data into a form that is readable by the bridge **12** and a computer system.

[0038] Once the interface device **16** has the necessary communication data stored in its memory to permit the bridge **12** to communicate with the medical device **14**, the interface device **16** begins receiving device data from the medical device **14**. Once the interface device **16** starts receiving the medical device data, the processor-transceiver **100** of the interface device **16** begins using the stored data and protocol to convert the medical device data received from the medical device **14** to permit the medical device **14** to communicate with the bridge **12**. Once the processor-transceiver **100** has converted the medical device data to data readable by the bridge, the processor-transceiver **100** transmits that bridge readable data to the bridge wirelessly.

[0039] In order to communicate wirelessly with the bridge **12**, the processor-transceiver **100** initially can be in a listen mode at a predefined frequency. The bridge **12** broadcasts on this predetermined frequency, the value of the frequency it will be expecting to transmit and receive on. The processor-transceiver **100** at time zero, will operate in receive mode on channel 0 looking for a response. The processor-transceiver **100** will not transmit on any channel until a signal is detected from the bridge **12**. The processor-transceiver **100** then switches itself to the transmit-and-receive frequency expected by the bridge **12**. At this point the bridge **12** instructs the processor-transceiver **100** to collect and transmit data. After each transmission from the processor-transceiver **100**, the bridge **12** issues an acknowledgement (ACK). If the processor-transceiver **100** fails to receive an ACK it returns to listen mode to determine if the bridge **12** has changed transmission frequencies.

[0040] In another embodiment, as shown in FIG. **5**, the interface device **16** includes both a wired and wireless communication options. The medical device is electrically connected to both the conversion circuit **26** and the processor-transceiver **100**. In this embodiment, the information collected by the medical device **14** can be transmitted through a USB cable via the conversion circuit **26** or wirelessly through the processor-transceiver **100** to the bridge **12**. This system includes a multiplexer (MUX) **200**, in electrical communication with the conversion circuit **26** and the processor-transceiver **100**. The MUX **200** also can be electrically connected to the memory **18**. The MUX operates to either transmit data from conversion circuit **26** to the MUX **200** and then to the memory **18**, or from the processor-transceiver **100** to the MUX **200** and then to the memory **18**.

[0041] When the conversion circuit **26** is being used to transmit data to the bridge **12**, the medical device sends data to the conversion circuit **26**. The conversion circuit **26** then communicates with the MUX **200**. The MUX **200** then accesses the memory **18**. As discussed above, the memory **18** is programmed to identify and communicate with various electronic devices. Thus, through the MUX **200**, the conversion circuit **26** can access the memory **18** to convert the data from the medical device **14** into data that can be read and processed by the bridge **12**. Finally, the conversion circuit **26** transmits the processed information to the bridge **12**.

[0042] When the processor-transceiver **100** is being used to transmit data wirelessly to the bridge **12**, the medical device **14** is electrically connected to the processor-transceiver **100**. The processor-transceiver **100** receives serial data from the medical device **14**. The MUX **200** permits communication between the processor-transceiver **100** and the memory **18**. Through communication with the memory **18**, the processor-transceiver **100** can take the medical device data and convert the medical device data into data that can be read and processed by the bridge. An antenna **128** is connected to the processor-transceiver **100** to transmit the converted data wirelessly to an antenna **132** associated with the bridge **12**.

[0043] Variations, modification, and other implementations of what is described herein will occur to those of ordinary skill in the art without departing from the spirit and scope of the invention as claimed. Accordingly, the invention is to be defined not by the preceding illustrative description, but instead by the spirit and scope of the following claims.

What is claimed is:

1. A wireless interface device for communication between an medical device and a bridge comprising:
- a processor-transceiver;
- a memory in electrical communication with the processor-transceiver; and
- a wireless transmitter in electrical communication with the processor-transceiver and in wireless communication with the bridge,
- wherein the memory contains communication data to instruct the processor-transceiver how to communicate with the medical device.

2. The wireless interface device of claim **1**, wherein the processor-transceiver comprises a micro-controller.

3. A system for communication between a computer and an medical device comprising:
- a bridge;
- a processor-transceiver in wireless communication with the bridge;
- a memory in electrical communication with the processor-transceiver; and
- the medical device in electrical communication with the processor-transceiver,
- wherein the memory contains communication data to instruct the processor-transceiver on how to communicate with the medical device.

4. A method of communicating between an medical device and a bridge comprising the steps of:
- storing communication data to communicate with the medical device;
- receiving medical device data from the medical device;
- using the communication data to convert medical device data from the medical device to permit the medical device to communicate with the bridge; and
- transmitting the communication data wirelessly to the bridge.

5. A system for communication between a medical device and a bridge comprising:
- a medical device;
- a conversion circuit in electrical communication with the medical device;
- a processor-transceiver in electrical communication with the medical device;
- an antenna in electrical communication with the processor-transceiver;
- a multiplexer in electrical communication with both the conversion circuit and the processor-transceiver; and
- a memory in electrical communication with the multiplexer,
- wherein the multiplexer permits either the conversion circuit or the processor-transceiver to communicate with the memory, and
- wherein the memory contains communication data to instruct the processor-transceiver on how to communicate with the medical device.

* * * * *