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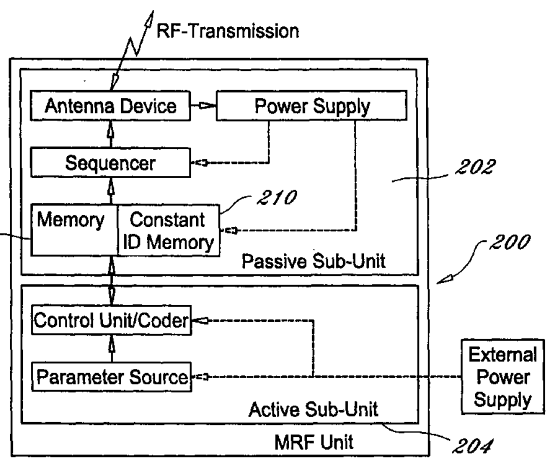

(57) Abstract: Disclosed is a device for capturing dynamic physical parameters and storing such parameters in non-volatile memory to allow an asynchronous read, via RF data transmission, of the parameters/values with no internal power associated with the device. In the preferred embodiment, the device is structured into two internal subunits. The first subunit is used to capture/measure physical parameters. The captured parameters are associated with an internal ID and combined into a bit stream that can be secured by error correction and error detection codes. The second subunit transmits the bit stream preferably via an antenna device using a RF mechanism. The second subunit can behave like a passive RF transporter, and does not require an internal battery backup or external power supply, whereas the first subunit preferably is provided with an external power supply or batteries. In one embodiment, the RF protocol of the device can conform to common RF-ID protocols used to transmit unique transponder IDs. Thus, standard RF-ID interrogators can be used to read the captured parameters and associated ID. In other embodiments, proprietary RF protocols can be incorporated that allow for transmission of extended amounts of data, including multiple time/date stamped logged parameters.

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DATA CAPTURE AND LOGGING WITH PASSIVE RF TRANSMISSION

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates generally to radio frequency transponders and, particularly, to a radio frequency transponder capable of capturing dynamic physical parameters and transmitting the parameters to a remote destination with passive radio frequency transmission.

2. Description of Related Art

Radio frequency identification technology typically involves two major components consisting of a transponder and a interrogator/reader. The transponder is typically an electronic component containing digital circuits and an antenna. The digital information can be read-only (i.e. bar codes) or read-write. The transport or transmission of the information to and from the transponder is often performed through the use of an RF signal. The interrogator typically reads information from the transponder and may also write information into the transponder. Certain common frequencies for the radio frequency fields currently in use are 125 KHz or 13.5 MHz. Additionally, relatively very high frequencies in the range of 2.4GHZ are also sometimes found.

The interrogator uses radio energy to provide an energizing field, which powers up the transponder in the field and enables the transponder to return its identity back to the interrogator/reader.

Transponders originally consisted of electronic circuits which were associated with an item for determining the location or existence of the item (i.e. identification tags). Upon receiving an interrogation request from an interrogator, the transponder either returned data (i.e. identity code or original properties of the signal received from the interrogator) to permit ranging measurements based on time of flight. The transponder moved some property of the initially received interrogator signal in the form of a returned signal such that the two signals could be detected simultaneously without one replacing the other. To achieve this simultaneous detection, the transmission frequency for each signal is different.

Different types of transponders currently are in use. Once commonly used transponder is a magnetically coupled transponder system which usually operates at frequencies typically in the order of 125 KHz. These transponders are generally characterized by antenna systems that are comprised of numerous turns of a fine wire around a coil former to collect energy from a reader's magnetic field. The range of the magnetic coupling is determined by the fields generated between the poles of the reader (interrogator). As mentioned above, the energizing signal is often at a frequency of 125 KHz causing data to be transmitted to the reader from the transponder. However, transponder systems which operate on magnetic coupling principles have been known to operate at frequencies as high as 29 MHz.

Electric field coupled transponders use the electric field propagation properties of radio communication to convey energy and data from the interrogator to the transponder and data from the transponder to the interrogator. Electric field propagation requires antenna systems that are typically half a wavelength of the operating frequency in size.

Radio frequency identification (RFID) makes use of the properties of radio frequency propagation by allowing energy to be radiated from a source and collected by a transponder which replies by radiating a response. To reduce costs, the transponder is often powered up with its energy requirements from a field radiated by the interrogator. This type of transponder system is often referred to as a "passive" transponder system. The interrogator radiates the energizing field towards the transponder for powering up the transponder. The frequency of the radiated energy field is set to the operating frequency allocated. The transponder collects part of the radiated energized field from its antenna and processes the energy for operating the transponder.

The transponder includes a memory element for storing the data to be transmitted when commanded by the interrogator. Typically memory embodiments include read only memory, read/write memory, etc. The transponder sends it data back to the interrogator usually in serial form. The interrogator is provided with an antenna for collecting the returned energy in the form of data from the transponder.

Another type of identification includes the use of bar codes. A barcode reader sends out energy in terms of light. Typically, this energy emission is performed by moving a beam of light across the barcode strip. Each character on the strip is represented by a pattern of wide and narrow bars. The barcode strips reflect portions of the energy depending on the bright or dark color of the stripes the beam of light is moving across. The barcode reader typically uses a photo sensor to convert the barcode into an electrical signal as it moves across the barcode. The scanner measures the relative widths of the bars and spaces, translates the different patterns back into regular characters, and sends them on to usually a computer or portable terminal. Thus, the barcode reader acts as an interrogator and receives an energy pattern from the barcode strip which acts as the transponder. Once the energy pattern is received, it can be decoded to data using any one of the plurality of conventional decoding schemes.

One drawback with barcode technology is the limitation on the type of information which can be transmitted to the barcode reader (interrogator). Barcode strips are not capable of receiving and transmitting dynamic data and merely provide static identification information. Accordingly, barcode technology cannot be used to monitor and measure continuously changing physical parameters of a machine, piece of equipment or other device. Other drawbacks with the use of barcode technology are that the barcodes can be easily copied or duplicated. Furthermore, if the barcode strips are dirty they may not be read properly or at all by the reader.

Thus, what is needed in the art is a transponder which is capable of capturing dynamic physical parameters and transmitting the parameters to a remote destination with passive radio frequency transmission. It is therefore to the effective resolution of the shortcomings of the prior that the present invention is directed.

BRIEF SUMMARY OF THE INVENTION

The present invention provides a radio frequency (RF) transponder device which can capture and transmit dynamic data, preferably in the format of a read-only identification (ID) to a remote destination such as an interrogator or reader. In the preferred embodiment the dynamic data represents physical parameters from a machine, equipment, other device, etc. The RF link between the transponder and interrogator preferably functions similar to a transformer. The primary winding of the interrogator induces energy into the secondary winding of the transponder at a specific frequency, such as at 125KHz, though such value is not considered limiting, and other frequencies can be used and are considered within the scope of the invention.

This induced energy powers up the internal electronic circuits of the transponder, causing the transponder to begin to shunt an associated coil (secondary winding) due to its bit stream and encoding schemes. This resulting pattern of energy consumption can be detected by the interrogator device and the pattern can be decoded using one of many decoding schemes.

Preferably, the RF transponder transmits dynamic data in the preferred format of a "read-only" ID. The dynamic data is preferably gathered from an internal parameter source. The parameter source can measure one or more physical parameters, including, but not limited to, pressure, temperature, voltage, time, etc. The measurements can be taken asynchronous (based on external events or conditions) or on a regular schedule. Each time a new measurement is performed, the resulting physical parameter is preferably converted into a chosen format of a read only RF-ID. The actual parameter is preferably stored within a non-volatile memory of the transponder. As such, the stored parameter information/data can be read by an interrogator even when no power is supplied to the transponder. Preferably, the last parameter available can be read by passive RF technology. A unique identification (ID) can also be associated with each transponder. Thus, the dynamic parameter value can be combined with the static ID into the read only ID format for transmittal. This combination allows a user, computer program, etc. to identify which specific transponder the parameter information was received from. This capability is helpful where more than one transponder is providing information or data to the interrogator.

In the preferred embodiment, the RF-ID protocol used to transfer information between the transponder and the interrogator is a sequence of bits (i.e. forty bits, though such is not limiting) that also preferably includes a unique number or other information to identify the specific transponder. Furthermore, additional bits can be provided including "check sums" and related information about the identifier. These additional bits can also be provided for error detection and error correction purposes.

The transponder dynamically constructs the preferred forty (40) bit information to be transmitted. The information space (i.e. 40 bits) is preferably statically (though not limiting) divided into two sections. The first section (i.e. 18 bits, though not limiting) stores the ID number/information. The ID information preferably remains static, as it merely identifies the particular transponder to which the parameter information is coming from. Thus, the transponder can be identified using the ID bits. The second section stores the dynamic data. As stated above, the dynamic data includes physical or other parameters, values or measurements that can change over time, which include but are not limited to, elapsed time, voltage, volume, weight, counts of specific events, etc. These parameters are preferably generated by a source, including necessary equipment to measure the particular physical parameter(s). Once generated the measurements are preferably first converted into digital format and then coded. The result of these steps is a number of information bits that represent the parameter data which can then be linked by identification bits to the specific transponder which captured and transmitted the parameter data.

The transponder captures dynamic physical parameters and stores the parameters in a non-volatile memory that allows for an asynchronous read of the values by RF data transmission with no internal power being supplied in the transponder. The device, preferably enclosed within a substantially rigid housing or casing, is structured into two preferred internal subunits:

(1) active subunit - capture/measure physical parameter(s) and combining the parameter(s) with an internal ID to derive a bit stream that is preferably secured by error correction and error detection codes; and

(2) passive subunit - transmitting the bit stream via an antenna device using conventional RF mechanisms, no internal battery backup or external power supply is needed.

The RF protocol of the transponder preferably conforms to conventional RF-ID protocols used to transmit unique transponder IDs. Thus, conventional RF-ID interrogators can be used to read the captured parameter information along with the ID for the transponder. Additionally, proprietary RF protocols can be used that allow for transmission of extended amounts of data such as, but not limited to, multiple time/date stamped logged parameters.

Accordingly, it is an object of the present invention to provide a transponder which can capture, measure and transmit dynamic data representing physical parameters to an interrogator.

It is another object of the present invention to provide a transponder which can capture or measure and transmit dynamic data to a remote destination.

It is still another object of the present invention to provide a transponder which can capture or measure and transmit dynamic data to a remote destination using passive radio frequency transmission.

It is a further object of the present invention to provide a transponder which can capture or measure and transmit dynamic data preferably in the format of a read-only identification (ID).

In accordance with these and other objects which will become apparent hereinafter, the instant invention will now be described with particular reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

The invention may be better understood by reference to the drawings in which:

Figure 1 is a block diagram of a first embodiment for the RF transponder in accordance with the present invention, having an internal power supply (i.e. battery);

Figure 2 is a block diagram of the first embodiment of the RF transponder, having an external power supply;

Figure 3 is a block diagram of one embodiment for the temperature parameter source in accordance with the present invention;

Figure 4 is a block diagram of one embodiment for the power consumption parameter source in accordance with the present invention;

Figure 5 is a block diagram of one embodiment for the event counter parameter source in accordance with the present invention;

Figure 6 is a block diagram of one embodiment for the digital input parameter source in accordance with the present invention;

Figure 7 is a block diagram of the first embodiment of the RF transponder illustrated in Figure 1, wherein the parameter source is a data interface;

Figure 8 is a block diagram of the first embodiment of the RF transponder illustrated in Figure 2, wherein the parameter source is a data interface;

Figure 9 is a block diagram of the first embodiment of the RF transponder illustrated in Figure 2, wherein the parameter source is a timer/counter;

Figure 10 is a block diagram of one embodiment for the timer (counter) parameter source in accordance with the present invention;

Figure 11 is a block diagram of one embodiment for the control unit/coder in accordance with the present invention.

Figure 12 is a flowchart representing the general steps performed by the active subunit of the RF transponder in accordance with the present invention;

Figure 13 is a block diagram illustrating the coded data bit stream transmitted by the RF transponder in accordance with the present invention;

Figure 14 is a schematic of one embodiment for the antenna in accordance with the present invention;

Figure 15 is a schematic of one embodiment for the power supply of the passive unit portion of the transponder in accordance with the present invention;

Figure 16 is a block diagram of one embodiment for the sequencer in accordance with the present invention;

Figure 17 is a block diagram illustrating a first alternative embodiment for the RF transponder in accordance with the present invention;

Figure 18 is a block diagram illustrating a second alternative embodiment for the RF transponder in accordance with the present invention;

Figure 19 is a block diagram illustrating a third alternative embodiment for the RF transponder in accordance with the present invention;

Figure 20 is a flowchart representing the general steps performed for a static burst calculation in accordance with the present invention;

Figure 21 is a flowchart representing the general steps performed for a dynamic burst calculation in accordance with the present invention;

Figure 22 is a block diagram illustrating a further alternative embodiment for the RF transponder in accordance with the present invention;

Figure 23 is a block diagram illustrating a standard bit stream burst transmission in accordance with the present invention;

Figure 24 is a block diagram illustrating a multi bit stream burst transmission in accordance with the present invention;

Figure 25 is a diagram illustrating the ring buffer data storage element in accordance with the present invention;

Figure 26 is a block diagram illustrating another alternative embodiment for the RF transponder in accordance with the present invention;

Figure 27 is a block diagram illustrating the coded data bit stream transmitted by the alternative embodiment RF transponder illustrated in Figure 26;

Figure 28 is a block diagram illustrating a multi bit stream burst transmission in accordance with the present invention having real time clock data; and

Figure 29 is a flowchart representing generally the steps performed by the control unit of the alternative embodiment RF transponder of Figure 26.

DETAILED DESCRIPTION OF THE INVENTION

As seen in Figure 1 a radio frequency (RF) transponder in accordance with a first embodiment of the present invention is illustrated and generally designated as transponder 30. In one embodiment transponder includes a passive sub-unit 40 and an active sub-unit 60. Passive unit 40 provides RF transmission, through antenna 42, of parameter values stored in memory 48, preferably including ID information, in a suitable RF protocol. Passive unit 40 preferably includes an antenna 42, power supply 44, sequencer 46, and memory element 48, which are in communication with each other. Memory 48 is preferably a non-volatile memory, though such is not limiting. An active power supply is not required with passive sub-unit 40.

Active sub-unit 60 preferably includes a constant ID memory 62, control unit/coder 64, parameter source 66 and a power supply. In one embodiment, the power supply can be an internal power supply such as a battery. In another embodiment, the power supply can be an external power supply 70. Active sub-unit 60 acquires the parameter data for the machine or device associated with transponder 30, and constructs a bit-stream which preferably consists of specific transponder 30 ID data, parameter data and error detection/correction information. Parameter source 66 is preferably in communication with one or more sensoric line(s) 67 which are in communication with the relevant environment or circuitry or components of a particular machine, equipment, device, item, etc. Where the identification of the transponder (i.e. when only one transponder will be used) is not required the constant ID memory can be eliminated.

Parameter source 66 is designed to measure physical parameters and convert the values of the measured parameters into a suitable format for transmission by passive subunit 40. Some parameter sources that can be measured include, but are not limited to, (1) hour-meter (i.e. time unit counter); (2) temperature; (3) power consumption; (4) event counter; (5) flow meter; (6) high/low watermarks (i.e. digital inputs); and (7) data interfaces (i.e. RS232). Preferably, the parameters are converted into a bit stream of a fixed length. In one embodiment, the length of the bit stream can be twenty two (22) bits, though such is not considered limiting and other number of bits can be used and are considered within the scope of the invention. The conversion can be performed by parameter source 66 or can be performed by control unit 64.

To measure the temperature parameter source, a resistor 66b (Figure 3) is preferably provided with either a negative or positive temperature coefficient. Preferably, two sensoric lines 67 are connected at each of the externally disposed resistor. Power is supplied to the resistor preferably from parameter source 66.

As seen in Figure 3, a block diagram of the preferred embodiment for the temperature parameter source 66a is illustrated, though such embodiment is not considered limiting. An internal power supply 66c maintains a high precision constant voltage 66d. The voltage source feeds a high precision resistor 66e, which maintains a constant resistance independent from temperature. However, external resistor 66b varies its resistance value as function of the temperature. This variation by resistor 66b can be measured as a variation in the voltage over internal high precision resistor 66e, given the constant resistance of resistor 66e. An analog to digital (A/D) converter 66f measures the voltage over resistor 66e and provides a digital representation of such on data bus 66i. Chip-enable (select) and Read/Write (R/W) signals 66j activate the data output from A/D converter 66f or force into a tri-state mode to release data bus 66i. If the number of bits provided by A/D converter 66g exceeds the width of data bus 66i, the value should be accessed as a bytes sequence. In order to address these bytes, address bus 66h is used.

To measure a power consumption/voltage parameter source on an external power line, voltage is preferably measured by providing a shunt resistor 66s in the power line 66t (Figure 4). As the value of the shunt resistor is known, the current can be measured or determined by measuring the voltage over the shunt resistor. With this parameter source, two sensoric lines 67 from parameter source 66 are connected to the power line at each of the shunt resistor. When measuring power consumption/voltage, parameter source 66 is not required to provide any energy for the measurement.

As seen in Figure 4, a block diagram of the preferred embodiment for the power consumption parameter source 661 is illustrated, though such embodiment is not considered limiting. Current in external shunt resistor 66s causes a voltage which is divided by internal high precision resistor 66m. This voltage over high precision resistor 66m is measured by A/D converter 66n. A/D converter 66n measures the voltage over resistor 66m and provides a digital representation of such on data bus 66o. Chip-enable (select) and Read/Write (R/W) signals 66r activate the data output from A/D converter 66n or force into a tri-state mode to release data bus 66o. If the number of bits provided by A/D converter 66n exceeds the width of data bus 66o, the value should be accessed as a bytes sequence. In order to address these bytes, address bus 66q is used.

As identified above, event counting can be included as a parameter source 66. For this parameter source, an external switch is preferably provided to count mechanical events such as, but not limited to, rotations of a wheel (i.e. automotive applications), for fluid meters, for counting objects/items passing a mechanical barrier, etc. Parameter source 66 provides power to two sensoric lines 67 that are connected to the switch at each end of the switch. Thus, each time the switch is closed or opened, an internal counter, preferably located within control unit 64, is incremented. With this parameter source 66, non-volatile memory is used for storing the latest counter value during "power-off" periods.

As seen in Figure 5, a block diagram of the preferred embodiment for the event counting parameter source 67a is illustrated, though such embodiment is not considered limiting. Preferably, event counting parameter source 67a consists of four major components (1) anti-shatter 67b; (2) edge triggered counter 67c; (3) tri-state buffer/de-multiplexer 67d; and (4) address/signal coder 67e. Where the event counter is connected to a mechanical switch(es), the shatter of the switch contact may result in numerous open-close cycles to count. Therefore, anti-shatter circuit 67b is preferably provided, though not limiting, to eliminate high-frequency open-close states when using the mechanical switch(es). The output of anti-shatter circuit 67b is preferably a digital signal that corresponds to the state of the switch. Counter 67c, preferably edge triggered, is also preferably a binary counter that holds an internal binary counter value of a given length. The length typically, though not limiting, exceeds the width of a data bus 67f. As an example, the width of counter 67c can be thirty-two (32) bits, while a typical data bus width is eight (8) bits. The output of anti-shatter circuit 67b provides the input to counter 67c. Preferably, counter 67c operates upon positive or negative edges on the input line. When triggered by an edge, counter 67c increments its value, preferably, by one. Counter 67c can also be cleared (i.e. set to zero) by an external signal line 67g. Data output lines (counter value), preferably of thirty two bits, are connected or otherwise in communication with de-multiplexer 67d.

Buffer/De-multiplexer circuit 67d buffers preferably eight to thirty-two input lines, and provides these bits as output lines. The number of input lines corresponds to the width of counter 67c. Data select input lines 67h are responsible for selection of a set of eight lines from the thirty-two input lines. Where other number of input lines are provided, other number of lines per set can be used. Furthermore, the invention is also not limited to eight lines per set when thirty-two input lines are provided. By variation of data select lines 67h, all thirty two inputs can be read as output in sequence of four bytes. The output is connected or otherwise in communication with the data bus of transponder 30. Input lines to address/signal coder 67e are chip select/read-write 67i from the control unit, as well as address bus 67j, or some bits of such bus. Active chip select output lines 67k bring the connected de-multiplexer/buffer 67d into an output mode. Inactive chip select forces the connected de-multiplexer/buffer into tri-state mode. The chip select signal is generated from input lines R/W and Chip Select 67i coming from the control unit. Certain lines, such as two lines, from address bus 67j can be used to generate the data select output. From the point of view of the control unit, counter parameter source 67a behaves like four bytes of memory which can be addressed using address bus 67j. These memory locations store the total of thirty-two bits counter value. Additionally, a combination of address and R/W signals can be used to generate clear counter signal 67g.

Digital inputs, as a function of switch states (i.e. open or closed), can also be read by parameter source 66. Parameter source 66 provides a vector of bits representing the state of the number of switches. The switches are in communication with parameter source 66. Thus, high/low watermarks, door open/close states or any other binary states can be detected using switches. With this use of parameter source 66, power is preferably supplied by parameter source 66 to the external switches. Additionally, the invention is not limited to any number of switches.

As seen in Figure 6, a block diagram of the preferred embodiment for the digital input parameter source 67m is illustrated, though such embodiment is not considered limiting. Preferably, digital input parameter source 67m consists of three major components (1) anti-shatter array 67n; (2) tri-state buffer/de-multiplexer 67o; and (3) address/signal coder 67p. Where digital input parameter source 67m is connected to a mechanical switch(es), the shatter of the switch contact(s) may result in numerous open-close cycles to count. Therefore, anti-shatter array 67n is preferably provided, though not limiting, to eliminate high-frequency open-close states when using the mechanical switch(es). The output of anti-shatter array 67n is preferably a digital signal that corresponds to the state of the switch(es).

Buffer/De-multiplexer circuit 67o buffers preferably eight to thirty-two input lines, and provides these bits as output lines. The number of input lines preferably corresponds to the number of digital switches, such as, though not limiting, thirty-two bits. Chip-select signal 67r switches between tri-state and output mode. Data select input lines 67q are responsible for selection of a set of eight lines from the thirty-two input lines. Where other number of input lines are provided, other number of lines per set can be used. Furthermore, the invention is also not limited to eight lines per set when thirty-two input lines are provided. By variation of data select lines 67q, all thirty two inputs can be read as output in sequence of four bytes. The output is connected or otherwise in communication with the data bus of transponder 30. Input lines to address/signal coder 67p are chip select/read-write 67s from the control unit, as well as address bus 67t, or some bits of such bus. Active chip select output lines 67r bring connected de-multiplexer/buffer 67o into an output mode. Inactive chip select forces connected de-multiplexer/buffer 67o into tri-state mode. The chip select signal is generated from input lines R/W and Chip Select 67s coming from the control unit. Certain lines, such as two lines, from address bus 67t can be used to generate the data select output. From the point of view of the control unit, digital input parameter source 67m behaves like four bytes of memory which can be addressed using address bus 67t. These memory locations store the total of thirty-two bits counter value.

As seen in Figures 7 and 8 an internal data interface 72 can be included as part of active subunit 60 in lieu of or as the parameter source. Preferably, the data interface can be a RS232 interface, though other interfaces can be used and are within the scope of the invention. In this embodiment, the parameter source is not built in with respect to counting events or measuring physical parameters. Internal data interface 72 can be connected to or in communication with external equipment via data communication lines 74. The external equipment can be any device, machine, etc. that provides parameters through a data interface that is compatible with internal data interface 72. Accordingly, the external equipment can also include a software application running on a computer if the respective interfaces are compatible. Any parameter transmitted by the external equipment is recorded by data interface 72 and processed by control unit/counter 64, similar to if the parameter had been generated by an internal parameter source 66.

Where no external power is supplied or if the external equipment is powered "off" or not operating, transponder 30 transmits the last transmitted parameter through passive subunit 40 for later read-out. Several power supplies can be used with the present invention and all are considered within the scope of the invention. An external power supply embodiment, similar to power supply 70, can include incoming power lines associated with an external power supply for providing electrical power for active subunit 60. Alternatively, power can be provided to active subunit 60 from the relatively high amount of energy associated with certain data interfaces, such as RS232 interfaces, on their data communication lines or can be provided with separate power supply lines. In this alternative embodiment, the power is supplied to the other components of active subunit 60. This alternative power supply embodiment is preferably located internally within active subunit 60. As a further embodiment, battery or regenerative power sources can also be used and are also considered within the scope of the invention.

As seen in Figure 9, a timing device 80 can be provided in lieu of or as the parameter source. In this embodiment, no external sensor line(s) are required, and transponder 30 functions as an hour meter. Timing device 80 is active when external power is supplied, and inactive when no external power is present. Timing device 80 counts the time of activity (i.e. up-time or down time) in terms of one or more time units (i.e. hours, minutes, seconds, days, etc.). Timing device 80 preferably includes a counter for counting the chosen time unit(s) when powered up by external power supply 82.

Each time a new timer/counter 80 value is present, it is preferably processed by control unit/coder 64 similar to the other parameter sources discussed above. The latest counter value is preferably stored in non-volatile memory to survive the time period when no power is received from external power supply. When "powered up" again, timer/counter 80 continues counting time units beginning with the last counter value.

This process accumulates time units similar to as an hour meter does.

The preferred non-volatile memory can be a separate structural component preferably disposed within active subunit 60. Alternatively, timing device 80 can have a non-volatile memory built within. Additionally, existing memory 48 of passive sub-unit 40, which is also preferably non-volatile, can also be used to store the counter value and is also considered within the scope of the invention.

As seen in Figure 10, a block diagram of the preferred embodiment for the timer (counter) parameter source 80a is illustrated, though such embodiment is not considered limiting. Preferably, timer (counter) parameter source 80a consists of four major components (1) clock generator 67b; (2) edge triggered counter 80c; (3) tri-state buffer/de-multiplexer 80d; and (4) address/signal coder 80e. Upon power "up" the control unit clears counter 80c by generating a certain address in "write" mode, which causes coder 80e to generate a clear counter signal on line 80f.

Buffer/De-multiplexer circuit 80d buffers preferably eight to thirty-two input lines, and provides these bits as output lines. The number of input lines corresponds to the number of digital switches, such as, though not limiting, thirty-two. Data select input lines 80h are responsible for selection of a set of eight lines from the thirty-two input lines. Where other number of input lines are provided, other number of lines per set can be used. Furthermore, the invention is also not limited to eight lines per set when thirty-two input lines are provided. By variation of data select lines 80h, all thirty two inputs can be read as output in sequence of four bytes. The output is connected or otherwise in communication with the data bus of transponder 30.

Input lines to address/signal coder 80e are chip select/read-write 80g from the control unit, as well as address bus 80j, or some bits of such bus. Active chip select output lines 80i bring connected de-multiplexer/buffer 80d into an output mode. Inactive chip select forces connected de-multiplexer/buffer 80d into tri-state mode. The chip select signal is generated from input lines R/W and Chip Select 80g coming from the control unit. Certain lines, such as two lines, from address bus 80j can be used to generate the data select output. From the point of view of the control unit, digital input parameter source 80a behaves like four bytes of memory which can be addressed using address bus 80j. These memory locations store the total of thirty-two bits counter value.

Counter 80c, preferably edge triggered, is also preferably a binary counter that holds an internal binary counter value of a given length. The length typically, though not limiting, exceeds the width of a data bus 80k. As an example, the width of counter 80c can be thirty-two (32) bits, while a typical data bus width is eight (8) bits. The output of clock generator circuit 80b provides the input to counter 80c. Preferably, counter 80c operates upon positive or negative edges on the input line. When triggered by an edge, counter 80c increments its value, preferably, by one. Counter 80c can also be cleared (i.e. set to zero) by external signal line 80f. Data output lines (counter value), preferably of thirty two bits, are connected or otherwise in communication with de-multiplexer 80d. With a given clock rate the value of counter 80c represents the amount of elapsed time since power "up". The control unit stores the counter value into non-volatile memory. Control unit, preferably, adds a new counter value to its last stored counter value to increase the amount of elapsed time.

In order to determine which particular transponder transmitted a specific bit of parameter data or information, information identifying the specific transponder can be combined or added to the parameter data and transmitted therewith. In a preferred embodiment, a constant ID memory 62 is provided within active subunit 60 (stored internally) and contains a unique ID to identify the specific transponder 30. The unique ID can be any number of bits of information, and in one embodiment can be 18 bits long. Constant ID memory 62 is preferably a read only memory (ROM) having the ID bit information stored within. Constant ID memory 62 is preferably a non-volatile memory or coded by shortcuts/dip switches. Constant ID memory 62 can be accessed by control unit/coder 64, wherein control unit/coder 64 receives the unique ID from memory 62 and combines or adds with the bits of information representing a measured or monitored parameter source.

As seen in Figure 11, control unit/coder 64 is preferably constructed from an embedded controller or relatively small central processing unit (CPU) 64a, which includes program memory (ROM) 64b and temporary data storage (RAM) 64c. Though not shown, power supply lines are also provided. It should be understood that control unit/coder is not limited to the embodiment shown in Figure 11, and other embodiments can be used and are considered within the scope of the invention. Once control unit/coder 64 is powered up, it reads the latest dynamic parameter value from parameter source 66, data interface 72, or timer/counter 80. Control unit/coder also reads the unique ID (static information) from constant ID memory 62. As stated above, control unit/coder 64 combines these information bits (i.e. 18 bits and 22 bits, respectively) into a single stream of information that preferably conforms to the net information length of the specific RF protocol used by transponder 30. Control unit/coder 64 can also apply additional error detection and error correction information to the combined bit stream, as well as addition bits (i.e. start bit sequence, etc.). Once the final bit stream (i.e. 64 bits) is calculated and constructed, it is stored in memory 48 of passive unit 40, which is preferably a non-volatile memory, and is ready for transmission once commanded by a signal received from the interrogator.

As stated above, the power supply for active subunit 60 can either be an internal power supply 68 (i.e. battery, solar cells, regenerative energy sources, etc.) or an external power supply 70 (Figure 2). As also mentioned above, power can also be derived from external data lines when data interface 72 is used to obtain the parameter value(s). Where transponder 30 is monitoring or measuring parameter source(s) for a device/machine having moving parts (i.e. wheels, gears, motor, pistons, etc.) other power sources can also be developed and fed to active subunit 60, by converting or transforming the kinetic energy into electrical energy for powering up active subunit 60. However, power is not required to read any stored parameters in memory 48 of passive unit 40. This allows for asynchronous reads of any stored parameter(s) even when transponder 30 is powered off and no external power is available.

Antenna 42 receives electro-magnetic power preferably from an interrogator device (reader), often in the form of a harmonic field of 125KHz, though such value is not considered limiting. Antenna 42 is preferably provided with a switch for connecting and disconnecting antenna 42 from all other interrogator devices. The switch is preferably controlled by sequencer 46. Preferably, the interrogator recognizes a different inductivity in its own transmission antenna when connected as opposed to when disconnected, to allow the information stored in memory 48 to be transmitted from transponder 30 to the specific interrogator. One embodiment for antenna 42 is illustrated in Figure 14, though such embodiment is not considered limiting.

When antenna 42 is connected to the various components of transponder 30, the harmonic field created carries energy which can be used for powering the components of passive unit 40. This built-in or internal power supply 44 thus extracts energy from antenna 42 and supplies the energy in a preferably stabilized form to the various components (i.e. sequencer 46 and memory 48) of passive unit 40. One embodiment for power supply 44 is illustrated in Figure 15, though such embodiment is not considered limiting.

As mentioned above, stored within memory 48 are the sequence of bits received or transferred from active subunit 60 for transmission to the interrogator device. The sequence of bits preferably includes all error detection/correction information and all other sequence information such as, but not limited to, a "burst start" sequence. The number of bits stored within memory 48 preferably equals the total length of a burst (i.e. 64 bits) that will be transmitted to the interrogator. Information stored in memory 48 is preferably written into by control unit 64 of active subunit 60 and is preferably read by sequencer 46. As there may be powerless intervals between writes to memory 48 by control unit 64 and reads of the stored information by sequencer 46, memory 48 is preferably a non-volatile memory such as an EEPROM, flash memory chips, etc.

When passive subunit 40 is powered up by the external field of antenna 42, sequencer 46 reads the bit stream/information stored within memory 48. This bit stream will be transmitted from memory 48 through antenna 42. For each bit set to logical "1" or "0", antenna 42 is connected or disconnected. Sequencer 46 also preferably derives a clock signal from antenna 42 to transmit the stored information in memory 48 synchronously to the frequency of the external field (i.e. 125 KHz). Once the entire bit stream (i.e. a burst having 64 bits) is transmitted, sequencer 46 reads the next bit stream stored in memory 48 for the next burst transmission. This repeated read of memory 48 allows for parameter changes by active subunit 60 even when passive subunit 40 is powered up and the information is being transmitted by antenna 42 to the intended interrogator.

One embodiment for the internal structure of sequencer unit 46 is illustrated in Figure 16, though such embodiment is not considered limiting. A clock generator 46a, which can be derived from a signal from antenna 42, generates a digital clock signal to feed counter 46b. The counter value is used an input from counter 46b to coder 46c. Coder 46c generates various signals from the received counter value, including, but not limited to: (1) shift register clock (the clock rate of bit modulation of antenna 42); (2) RW/CS signals (the EEPROM of passive unit40 is selected and activated using these signals); (3) address signals (in order to read the sixty-four bits to be transmitted, the EEPROM should be addressed in eight bytes, if the EEPROM is organized bytewise); and (4) clear counter (once the entire bit sequence, i.e. sixty-four bits, has been transmitted, counter 46b is cleared by this signal generated by coder 46c.

A first alternative embodiment is illustrated in Figure 17, wherein the sequencer and the control unit/coder of transponder 100 are combined within a single component 110.

This embodiment is preferably desirable where there is not a demand for a relatively high-speed CPU device in active subunit 104. Thus, a single relatively low-power controller 110 can act as both the sequencer of passive subunit 102 and the control unit/coder of active subunit 104 to help reduce cost and aid in miniaturization of a commercial embodiment of the invention. If not specifically mentioned, all other components of transponder 100, as well as for the other transponder embodiments discussed below, are similar in structure and function with like components of transponder 30.

Additionally, intelligent sequencers can be included for combining the identification information received from the constant ID memory into the bit stream. In this embodiment the constant ID memory could be located within passive subunit 40 or 102.

As seen in Figure 18, another alternative embodiment of the invention is illustrated and generally designated as transponder 200. In this embodiment constant ID memory 210 is implemented as a portion of memory 212 located within passive subunit 202 to reduce the number of components for transponder 200. Preferably, transponder 200 cannot write into constant ID memory, to allow the bits of information stored in constant ID memory to remain unchanged after manufacture. Additionally, any additional memory (i.e. non-volatile memory) needed for hour meter/counter applications can also be included as a logical area or portion of the single memory component 212.

As seen in Figure 19, a combination of the alternative embodiments shown in Figures 17 and 18 can be implemented to yield a relatively very compact design for a transponder 300 in accordance with the present invention. In this embodiment both the integrated memory 310 (preferably non-volatile) and the integrated controller/sequencer 312 are implemented. Additionally, further integration can also result in a further compact hybrid or even a single ASIC design. Furthermore, other combinations of the various embodiments of the present invention can also be implemented and are all considered within the scope of the invention.

As stated above, in the preferred embodiment, the burst bit stream consists of the net information bits (i.e. 40 bits) and error detection/correction bits (i.e. check sums, CRC information). In this embodiment, a burst start information sequence frames the single bursts. As an alternative, instead of calculating the additional information prior to saving it in memory 48 of passive subunit 40 (static burst calculation), sequencer 46 can be provided with the necessary computing power to calculate the additional error-related information on the "fly" (dynamic burst calculation). In this embodiment, only the net information bits are stored in memory 48.

As seen in Figure 22, a further embodiment for the present invention is illustrated and generally designated as transponder 360. In this embodiment, power supply 366 of passive subunit 362 is also used to power up active subunit 364. In this embodiment, the components of active subunit 364 have relatively low-power consumption characteristics.

As previously mentioned, in the preferred embodiment the RF transmission uses a specific protocol that transmits a number of information bits (i.e. 40 bits) along with error detection/correction information and burst start bits (i.e. totaling 64 bits). This transmission of the burst information is repeated continuously. As an alternative transmission technique a multi-burst characteristic can be employed which extends the length of information (i.e. number of bits) by transmitting multiple standard bursts containing different information in each burst. A comparison of the preferred and alternative transmission methods are illustrated in Figures 23 and 24. Typically, the RF receiver reads the information two or more times for security reasons. Thus, the number of different bursts is preferably limited to a useful number that allows multiple reads of all bursts with a reasonable timeframe.

Using the multi-burst transmission (Figure 24), transponder 30 can function as a data logging device. Transponder 30 can record a number of parameters along with a time/date stamp. The number of logs preferably corresponds to the number of bursts implemented to transmit the information.

As seen in Figure 25, a data storage ring buffer 400 can be used where the oldest data log information is overwritten by the latest data log information. The receiver of the information preferably determines which is the latest and the oldest logs.

From Figure 25 it is seen that Log 0 represents the latest log, log -1 was taken before log 0, log -2 was taken before log -1, etc. It is also seen that the oldest log in ring buffer 400 is log -7. Thus, ring buffer 400 contains eight (8) different logs. However, the number of logs chosen is by way of example only, and any number of logs can be used and is considered within the scope of the invention.

When a new log is to be stored in ring buffer 400, the oldest log (i.e. log -7) is written over and becomes new log 0. The previous log 0 becomes log -1, etc. The sequence from newest to oldest log is preferably always maintained. When transmitting the logs in multiple burst (Figure 25), the sequence of logs is preferably maintained. This helps to ensure that the receiving end of the data transmission can determine the "age" of each particular date log.

From a time-date stamp, the RF receiving site can determine if a particular data log was previously captured and transmitted. When using ring buffer 400 for data storage, it is preferred that the readout of each data log occurs within a maximum time interval. If not, the possibility exists that one or more data logs are written over before they were transmitted, thus, possibly causing their information/data to be lost. Thus, it is preferred that the parameters are automatically captured on a regular time schedule (i.e. once a day, once an hour, etc.). It is not necessary that the receiving site know exactly at what point in time was the parameters captured. Where the logs are captured automatically (i.e. every sixty minutes), all the receiving site is satisfied to know is that the latest log was captured within the last sixty minutes, and that any other log was captured sixty minutes prior to the log before, which if satisfied will avoid any inadvertent overwrites of data.

It is also not necessary that each log that is transmitted contain the ID information from constant ID memory 62. Only one of the bursts is required to contain the ID information, and preferably is the first in the sequence of information transmitted (See Figure 24). It should be recognized that there is no restriction on how the ID information and parameter/data logs are included in the transmission. They can be included in each burst or cross multiple bursts. However, the receiving end must be able to organize or gather the information from multiple burst and reconstruct the individual pieces of information.

Where asynchronous parameter logging is used, additional time/date stamping of the logs is preferably performed in order to determine the exact date/time for each individual log. To accomplish this additional stamping a real time clock 90 is preferably provided (Figure 26). Real time clock 90 is preferably backed up by an internal battery 92 that should last at least for several years. In this embodiment (Figure 26), when a log occurs, control unit 64 reads the data from real time clock 90 and combines the clock data with the parameter value information into a final bit stream for storage into memory 48. Here the combined net data bit stream (parameter values - dynamic data and clock 90 time stamp) can extend into one bit net information burst (i.e. 40 bits). Depending on the RF protocol used, one or more logs can be provided per burst or the logs can span multiple bursts. The ID information from constant ID memory 62 identifying the specific transponder 30 is preferably placed into one of the burst, such as the first burst. As previously mentioned, it is not necessarily to combine the ID information from constant ID memory 62 into each log.

When using a clock, such as real time clock 90, at some future point the clock may become out of synchronization with the receiver. Thus, to maintain correct date/time values, additional processing and logging can be performed by transponder 30. Each time passive subunit 30 is powered on (i.e. transmission of the log information is being carried out), control unit 64 should also be powered on as well. In this embodiment, power supply 44 of passive subunit 40 also powers control unit 64 of active subunit 60. When control unit 64 is powered on by power supply 44 it is programmed to preferably read only real time clock 90 and write a "dummy" log into memory 48 (i.e. non-volatile memory). This dummy log contains the actual date/time value of real time clock 90, but preferably does not contain a valid parameter value. This process is preferably repeated while power from power supply 40 is supplied to control unit 64.

When transmitting the entire sequence of bursts, the dummy log contains the actual date/time value of real time clock 90 when the transmission was carried out. The receiver (interrogator) preferably records its own actual date/time value when receiving the bursts. Subsequent evaluation of the logs, including their date/time stamps, can be performed regarding any difference in time between transponder 30 and the interrogator device. The procedure is preferably adaptive each time information is read from transponder 30 and can compensate even relatively large deviations. A sample of the burst sequence is illustrated in Figure 28, while Figure 29 illustrates control unit 64's flow process incorporating data from real time clock 90.

As seen in Figure 29, each time a new parameter value is logged, the value is gathered from parameter source 66, data interface 70 or timing device 80 and the actual real time clock 90 time/value is read. These two pieces (bits) of information are combined into one log. Once the net information is combined, and any additional error detection information is added, the complete log is written into memory 48 of passive subunit 40. Where a ring buffer 400 is provided, this new log becomes log 0 and all other previous logs are shifted, as described above. Once passive subunit 30 is powered on to carry out transmission of log information, control unit 64 continuously writes the first burst information containing the ID information from constant ID memory 62 and the actual date/time value from real time clock 90.

In all embodiments, the first and second subunits can be enclosed or disposed within a substantially rigid outer shell or casing.

Thus, summarizing the present invention provides a transponder for capturing dynamic physical parameters and storing such parameters in non-volatile memory to allow an asynchronous read, via RF data transmission, of the parameters/values with no internal power associated with the transponder. In the preferred embodiment, the transponder is structured into a first subunit used to capture/measure the dynamic physical parameters and a second subunit used for transmitting a bit stream preferably through an antenna device using a RF mechanism or protocol. To obtain the bit stream for transmittal, the captured parameters from the first subunit are associated with an internal ID and combined to form the bit stream which can also be secured by error correction and error detection codes. The second subunit can behave like a passive RF transporter, and does not require an internal battery backup or external power supply, whereas the first subunit preferably is provided with an external power supply or batteries. In one alternative embodiment the first active subunit is powered from the second passive subunit. In one embodiment, the RF protocol of the device can conform to common RF-ID protocols used to transmit unique transponder IDs. Thus, standard RF-ID interrogators and other readers can be used to receive the captured parameters and associated ID for further processing and/or analysis. A real time clock can also be included to provide a time/date stamp for the captured parameters. In other embodiments, proprietary RF protocols can be incorporated that allow for transmission of extended amounts of data, including multiple time/date stamped logged parameters. The transponder can be provided in a rigid or hard outer casing or shell.

In one embodiment, the transponder of the present invention can include the following specifications, though such specifications are not considered limiting:

PRODUCT		STANDARD
Processor	8 Bit RISC CPU	4 MHz
Clock	Accuracy	<1%
	Resolution	0.3 hours
	Capacity before roll over	15 years
	Clock data	22 bit
Identification	Unique ID	18 bits
Memory	RAM	256 Bytes
	ROM	1K Bytes
	EEPROM	1K Bytes
Power	Type	5.15V DC
	Current	1Ma
Physical Dimensions	Width	2.68" (68 mm)
	Height	1.73" (44 mm)
	Depth	0.91" (23 mm)
	Weight	Less than 8 oz.
Eviron. Conditions	Storage Temperature	-40°C To + 120°C
	Operation Temperature	-40C To 85°C
	Humidity	100o% non-condensing
Case	Material	ABS
	Color	Black
	Protection Class	IP 65
Interface	Type	RF-ID
	Transmission Speed	9600 Baud

The instant invention has been shown and described herein in what is considered to be the most practical and preferred embodiment. It is recognized, however, that departures may be made therefrom within the scope of the invention and that obvious modifications will occur to a person skilled in the art.

CLAIMS

What Is Claimed Is:

1. A transponder for capturing and transmitting dynamic data representing at least one physical parameter of a device, said transponder comprising:

means for capturing dynamic data representing at least one physical parameter of a device; and

means for passive RF transmitting of said dynamic data to a receiver.

2. The transponder of claim 1 further including means for converting said dynamic data into a digital format prior to transmitting said dynamic data to said receiver.

3. The transponder of claim 1 further including means for combining said dynamic data with identification information associated with said transponder.

4. The transponder of claim 3 wherein said means for capturing is a parameter source in communication with the device for receiving the dynamic data.

5. A transponder for capturing and transmitting dynamic data representing at least one physical parameter of a device, said transponder comprising:

an active subunit for capturing said dynamic data, said active subunit comprising a parameter source in communication with said device, a control unit/coder in communication with said parameter source, a constant ID memory in communication with said control/unit coder, and means for supplying power to said control unit/coder and said parameter source;

a passive subunit for transmitting the dynamic data to a remote destination upon command, said passive subunit including a memory element in communication with said control unit/coder, a sequencer in communication with said memory element and an antenna in communication with said sequencer;

wherein said dynamic data is received by said parameter source and combined by said control unit/coder with identification information received by said constant ID memory and converted into a digital format and stored within said memory element of said passive subunit;

wherein upon command said sequencer sends the converted dynamic data and identification information stored in said memory element to the remote location through said antenna by passive RF transmission.

6. The transponder of claim 6 wherein said means for supplying power is an internal battery.

7. The transponder of claim 5 wherein said means for supplying power is an external power supply.

8. The transponder of claim 5 wherein said means for supplying power is an internal power supply disposed within said passive subunit.

9. The transponder of claim 5 wherein said parameter source is a timing device.

10. The transponder of claim 5 wherein said parameter source is a data interface.

11. The transponder of claim 5 wherein said active subunit further including a real time clock in communication with said control unit/coder.

12. The transponder of claim 11 further including an internal power supply in communication with said real time clock.

13. The transponder of claim 5 wherein said parameter source in communication with at least one sensoric line.

14. The transponder of claim 13 wherein said dynamic data represents temperature measurements and wherein said at least one sensoric line is a pair of sensoric lines, said transponder further comprising an external resistor having a temperature coefficient connected between said pair of sensoric lines, said parameter source supplying power to said external resistor.

15. The transponder of claim 14 wherein said resistor having a negative temperature coefficient.

16. The transponder of claim 14 wherein said resistor having a positive temperature coefficient.

17. The transponder of claim 13 wherein said dynamic data represents power measurements and wherein said at least one sensoric line is a pair of sensoric lines connected to a power line to be monitored, said transponder further comprising a shunt resistor connected in series along the power line between the connection of the pair of sensoric lines to the power line.

18. The transponder of claim 13 wherein said dynamic data represents event measurements and wherein said at least one sensoric line is a pair of sensoric lines; said transponder further comprising a switch connected between the pair of sensoric lines; wherein each time said switch is closed or opened, an internal counter disposed within said control unit is incremented.

19. The transponder of claim 18 wherein said control

unit further including a non-volatile memory for storing a latest counter value during power off periods.

20. The transponder of claim 13 wherein said dynamic data represents digital input measurement; said transponder further comprising an external switch associated with each of said at least one sensoric line; said parameter source supplying power to said external switch.

21. The transponder of claim 5 wherein said memory element is a non-volatile memory.

22. The transponder of claim 5 further including a ring buffer data storage having a plurality of storage logs; wherein as new dynamic data is captured and converted into a transmittal format it is stored within a latest of said plurality of storage logs and all previously stored dynamic data is shifted over causing data stored in an oldest log of said plurality of storage logs to be overwritten.

23. A method for capturing and transmitting dynamic data representing one or more physical parameters of a device by a RF transponder using passive RF transmission; said method comprising the steps of:

(a) reading the dynamic data;

(b) converting the dynamic data to a transmittable format;

(c) storing the converted dynamic data in a memory;

(d) transmitting the stored information upon command to a remote location using passive RF transmission; and

(e) repeating steps (a) through (d) as necessary.

24. The method of claim 23 wherein step (c) comprises the step of storing the converted dynamic data in a non-volatile memory.

25. The method of claim 23 wherein step (d) comprises the steps of:

(d1) energizing the transponder from a signal received from an interrogator; and

(d2) transmitting the converted data to the interrogator by RF transmission.

26. A method for capturing and transmitting dynamic data representing one or more physical parameters of a device by a RF transponder using passive RF transmission; said method comprising the steps of:

(a) reading the dynamic data captured by a parameter source of the transponder;

(b) reading identification information associated with the RF transponder stored in a first memory of the transponder;

(c) combining the dynamic data and identification information and converting the combined data and information to a transmittable format;

(d) storing the converted data and identification information in a second memory of the transponder;

(e) transmitting the stored data and information upon command to a remote location using passive RF transmission; and

(f) repeating steps (a) through (e) as necessary.

27. The method of claim 26 further comprising the step of adding error correction/detection information and protocol bits to the combined data and information prior to storing in the second memory of the transponder.

28. The method of claim 26 further including the step of adding a real time clock value to the dynamic data prior to storing in the first memory of the transponder.

29. The method of claim 26 further including the step of adding a real time clock valued to the identification information prior to storing in the first memory of the transponder.

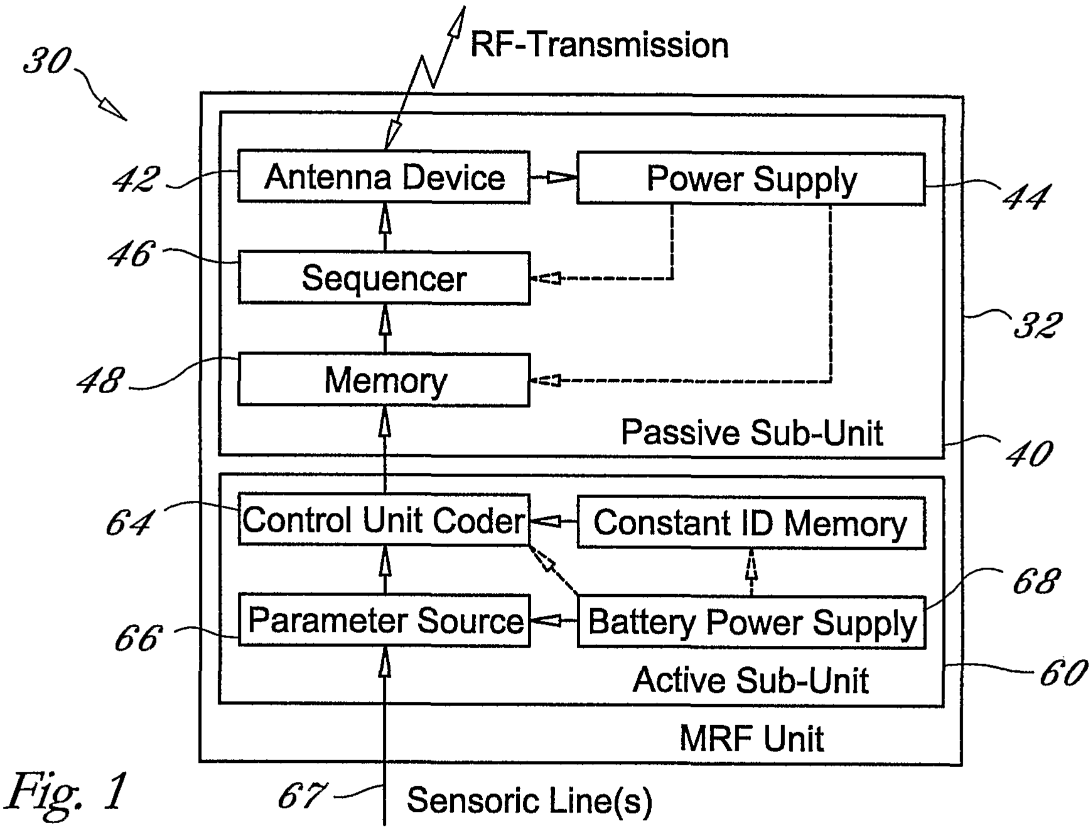

RF-Transmission
30
Antenna Device
Power Supply
42
44
Sequencer
46
32
Memory
48
Passive Sub-Unit
40
Control Unit Coder
Constant ID Memory
64
Parameter Source
Battery Power Supply
68
66
Active Sub-Unit
60
MRF Unit
67
Sensoric Line(s)

Fig. 1

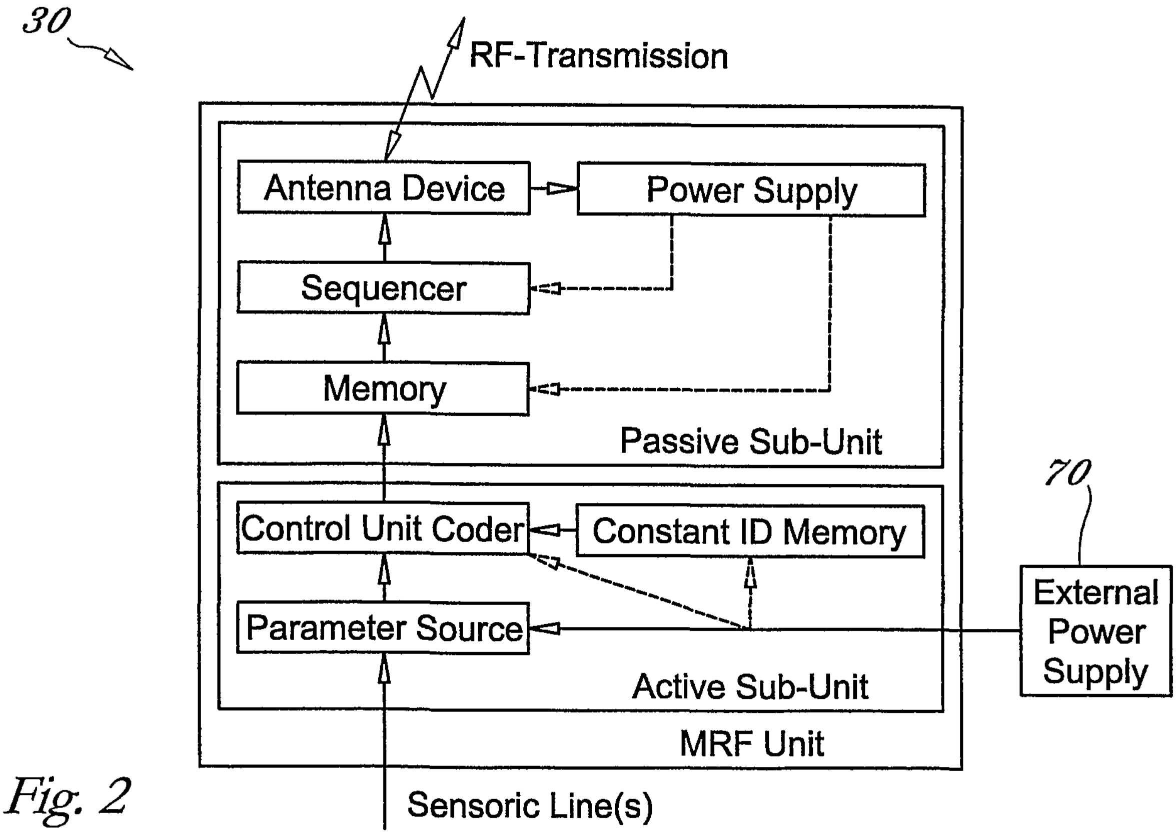

30
RF-Transmission
Antenna Device
Power Supply
Sequencer
Memory
Passive Sub-Unit
70
Control Unit Coder
Constant ID Memory
External Power Supply
Parameter Source
Active Sub-Unit
MRF Unit
Sensoric Line(s)

Fig. 2

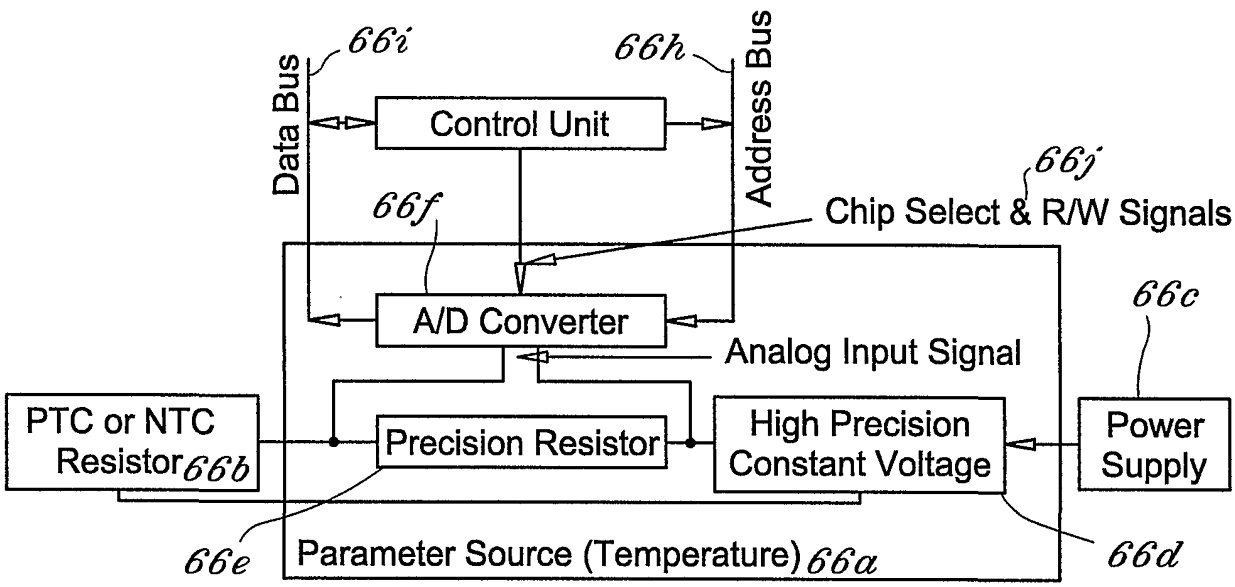
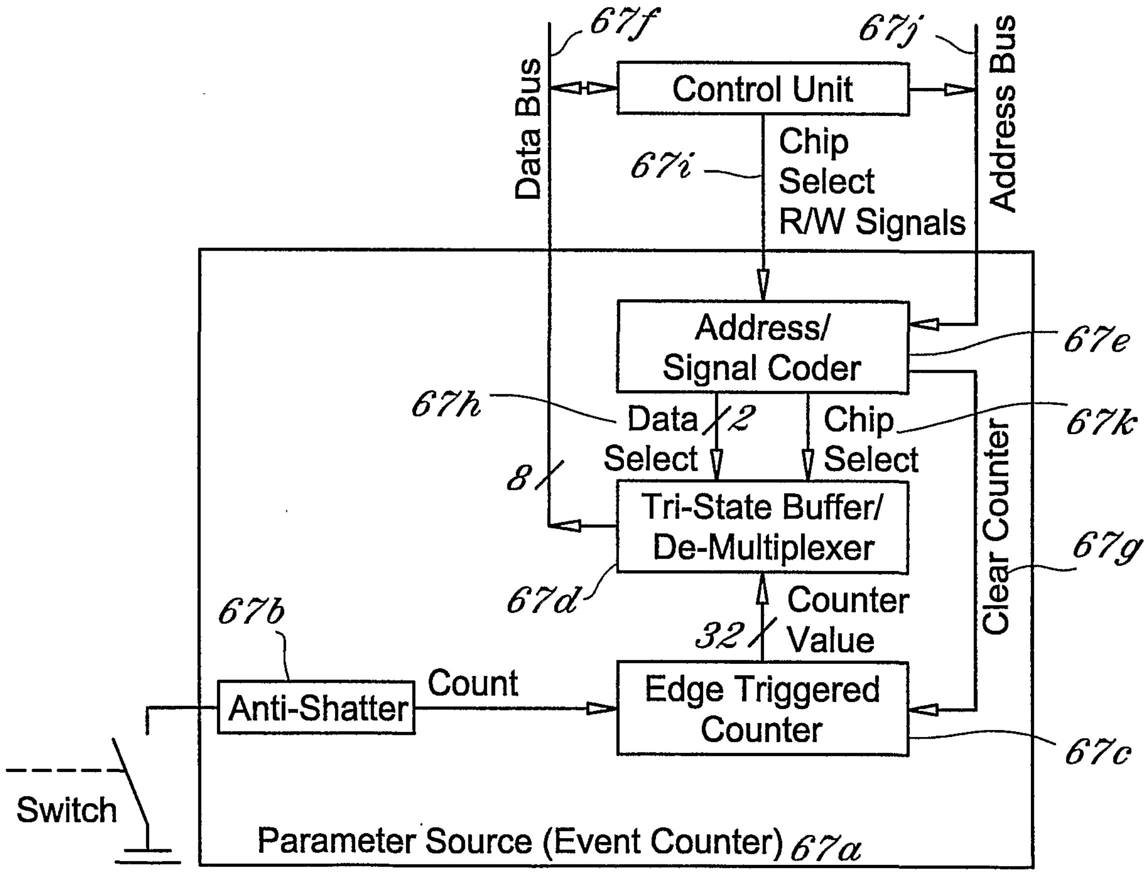

Data Bus
66i
66h
Address Bus
Control Unit
66j
Chip Select & R/W Signals
66f
A/D Converter
66c
Analog Input Signal
PTC or NTC Resistor 66b
Precision Resistor
High Precision Constant Voltage
Power Supply
66e
Parameter Source (Temperature) 66a
66d

Fig. 3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67j
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Address Bus
Control Unit
67i
Chip Select R/W Signals
Address/ Signal Coder
67e
67h
Data Select
2
Chip Select
67k
8
Tri-State Buffer/ De-Multiplexer
Clear Counter
67g
67d
Counter Value
32
67b
Anti-Shatter
Count
Edge Triggered Counter
67c
Switch
Parameter Source (Event Counter) 67a

Fig. 5

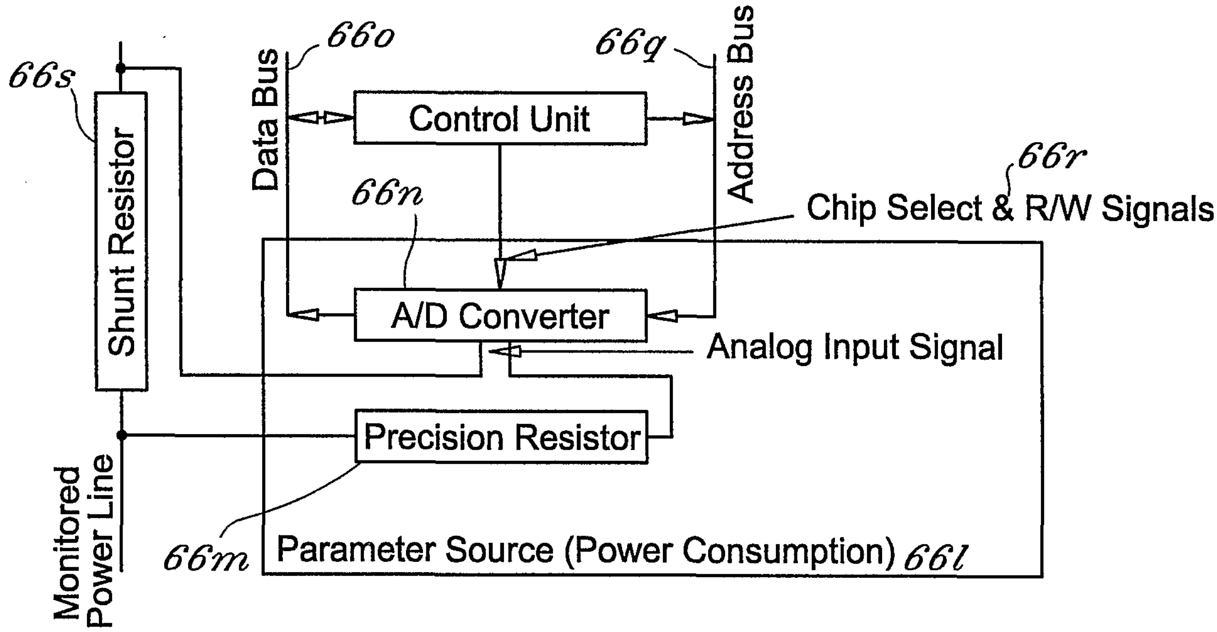
66s
Shunt Resistor
66o
Data Bus
Control Unit
66q
Address Bus
66r
Chip Select & R/W Signals
66n
A/D Converter
Analog Input Signal
Precision Resistor
Monitored Power Line
66m
Parameter Source (Power Consumption) 66l

Fig. 4

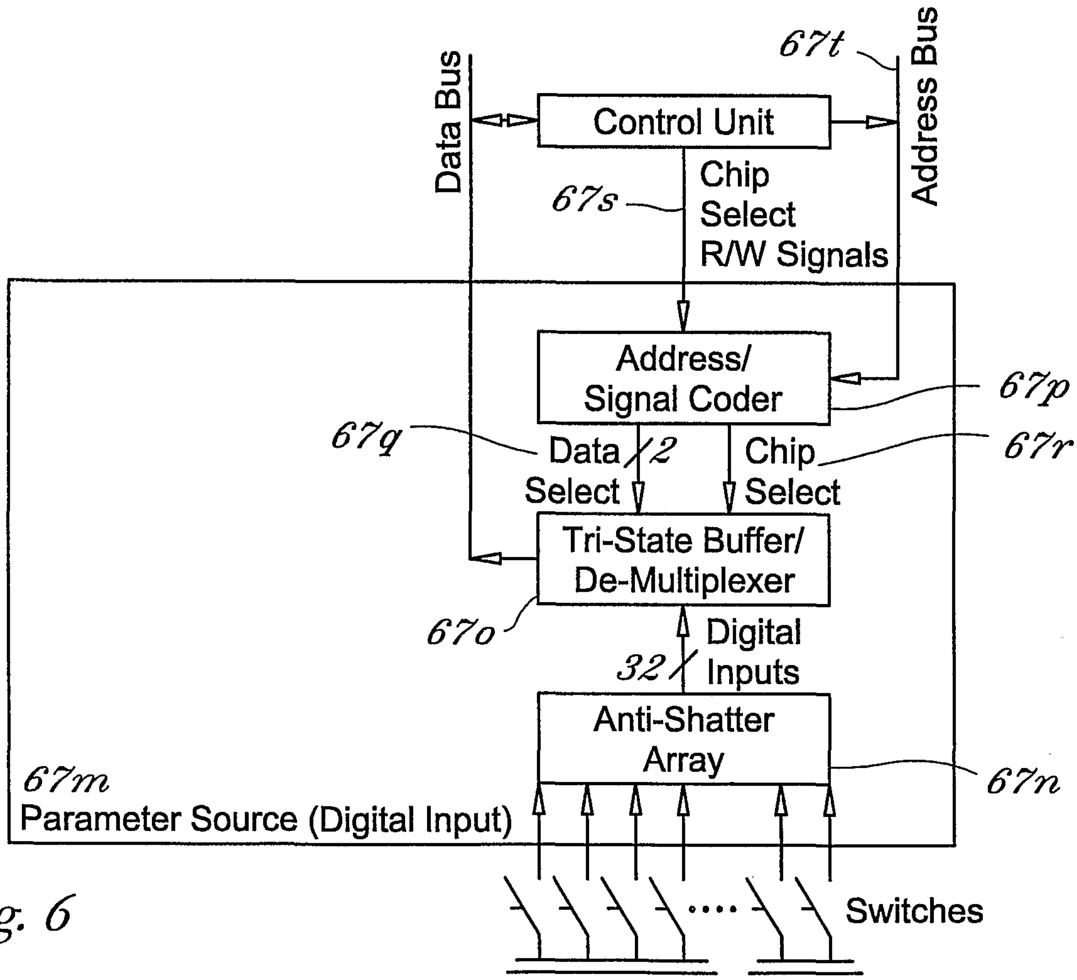
Data Bus
67t
Address Bus
Control Unit
67s
Chip Select R/W Signals
Address/ Signal Coder
67p
67q
Data Select
2
Chip Select
67r
Tri-State Buffer/ De-Multiplexer
67o
32
Digital Inputs
Anti-Shatter Array
67n
67m
Parameter Source (Digital Input)
Switches

Fig. 6

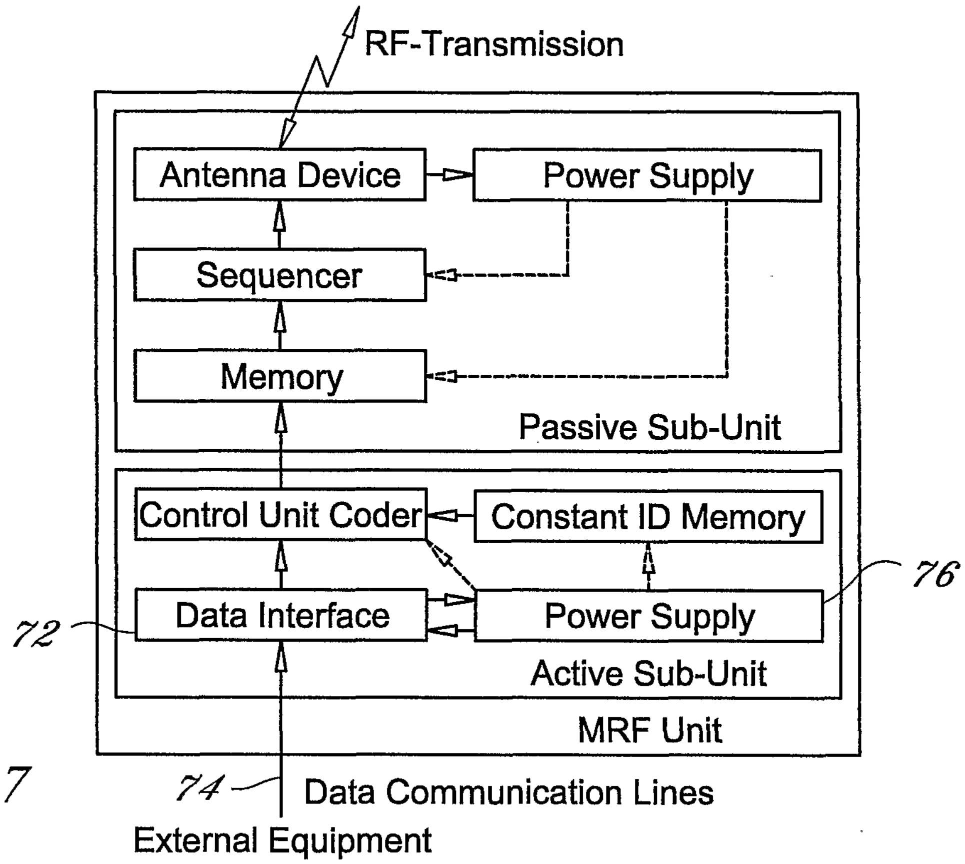
RF-Transmission
Antenna Device
Power Supply
Sequencer
Memory
Passive Sub-Unit
Control Unit Coder
Constant ID Memory
Data Interface
Power Supply
Active Sub-Unit
MRF Unit
72
74
76
Data Communication Lines
External Equipment

Fig. 7

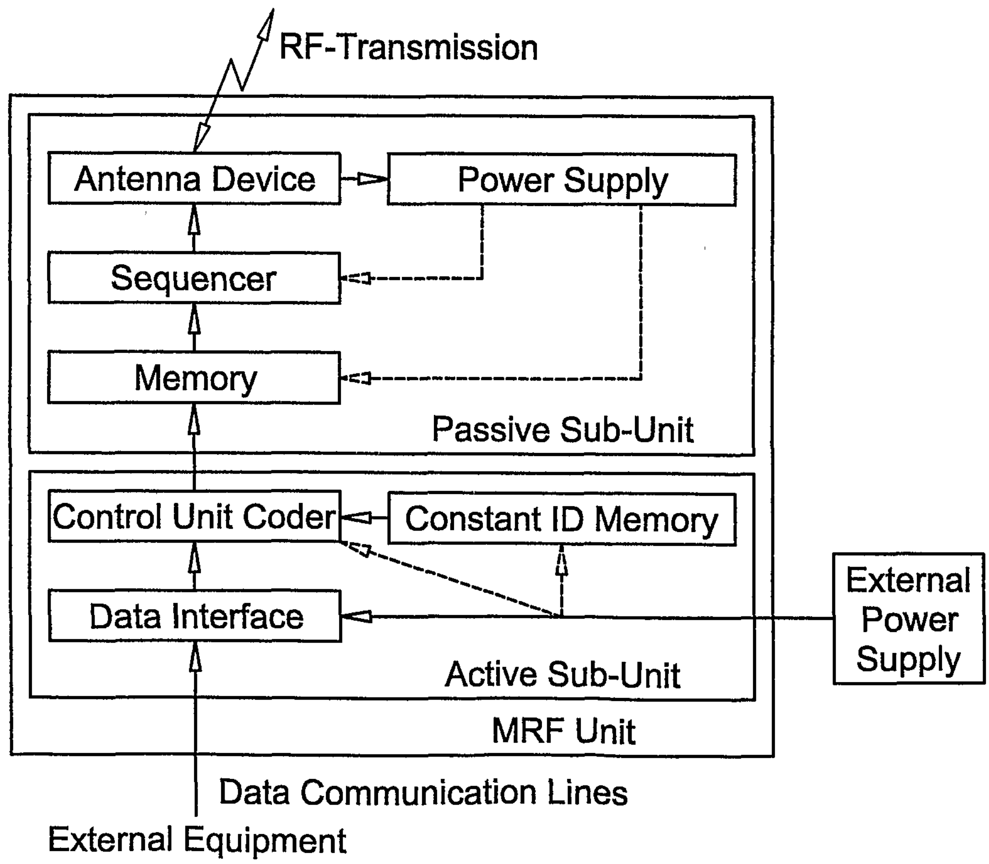
RF-Transmission
Antenna Device
Power Supply
Sequencer
Memory
Passive Sub-Unit
Control Unit Coder
Constant ID Memory
Data Interface
External Power Supply
Active Sub-Unit
MRF Unit
Data Communication Lines
External Equipment

Fig. 8

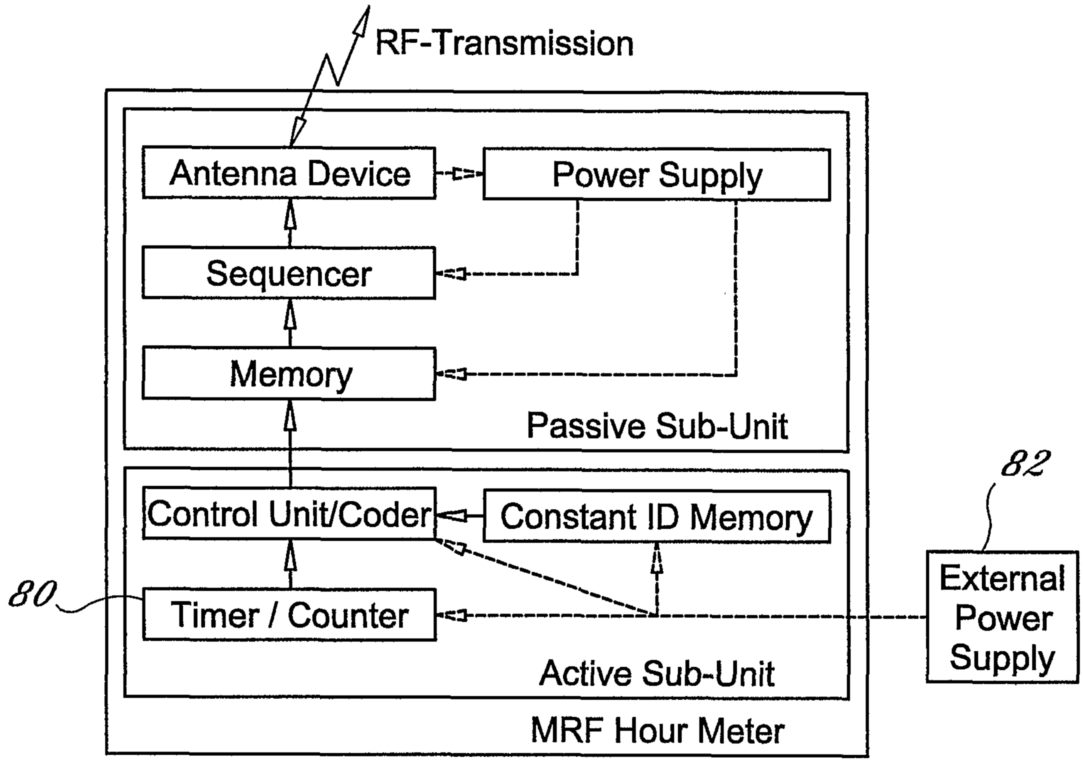
RF-Transmission
Antenna Device
Power Supply
Sequencer
Memory
Passive Sub-Unit
Control Unit/Coder
Constant ID Memory
80
Timer / Counter
Active Sub-Unit
MRF Hour Meter
82
External Power Supply

Fig. 9

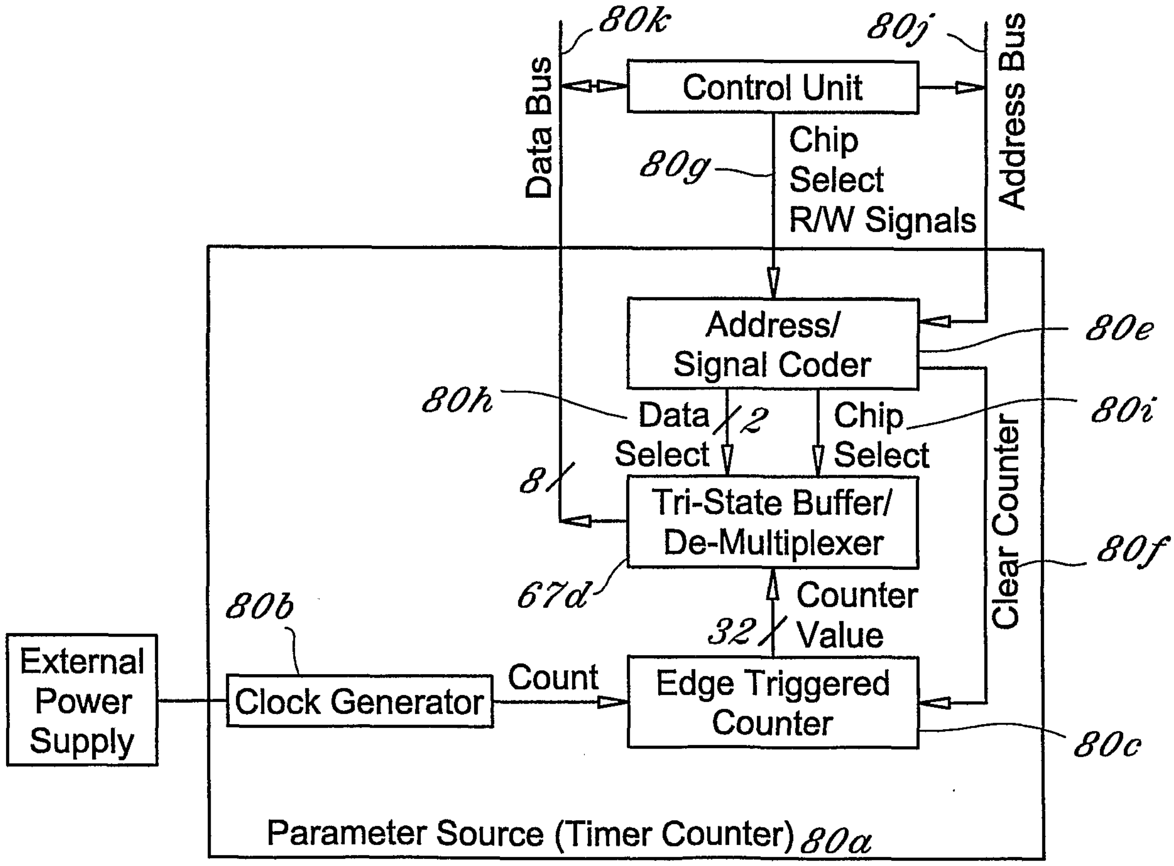
80k
80j
Data Bus
Control Unit
Address Bus
80g
Chip Select R/W Signals
Address/ Signal Coder
80e
80h
Data Select
2
Chip Select
80i
8
Tri-State Buffer/ De-Multiplexer
Clear Counter
80f
67d
80b
Counter Value
32
External Power Supply
Clock Generator
Count
Edge Triggered Counter
80c
Parameter Source (Timer Counter) 80a

Fig. 10

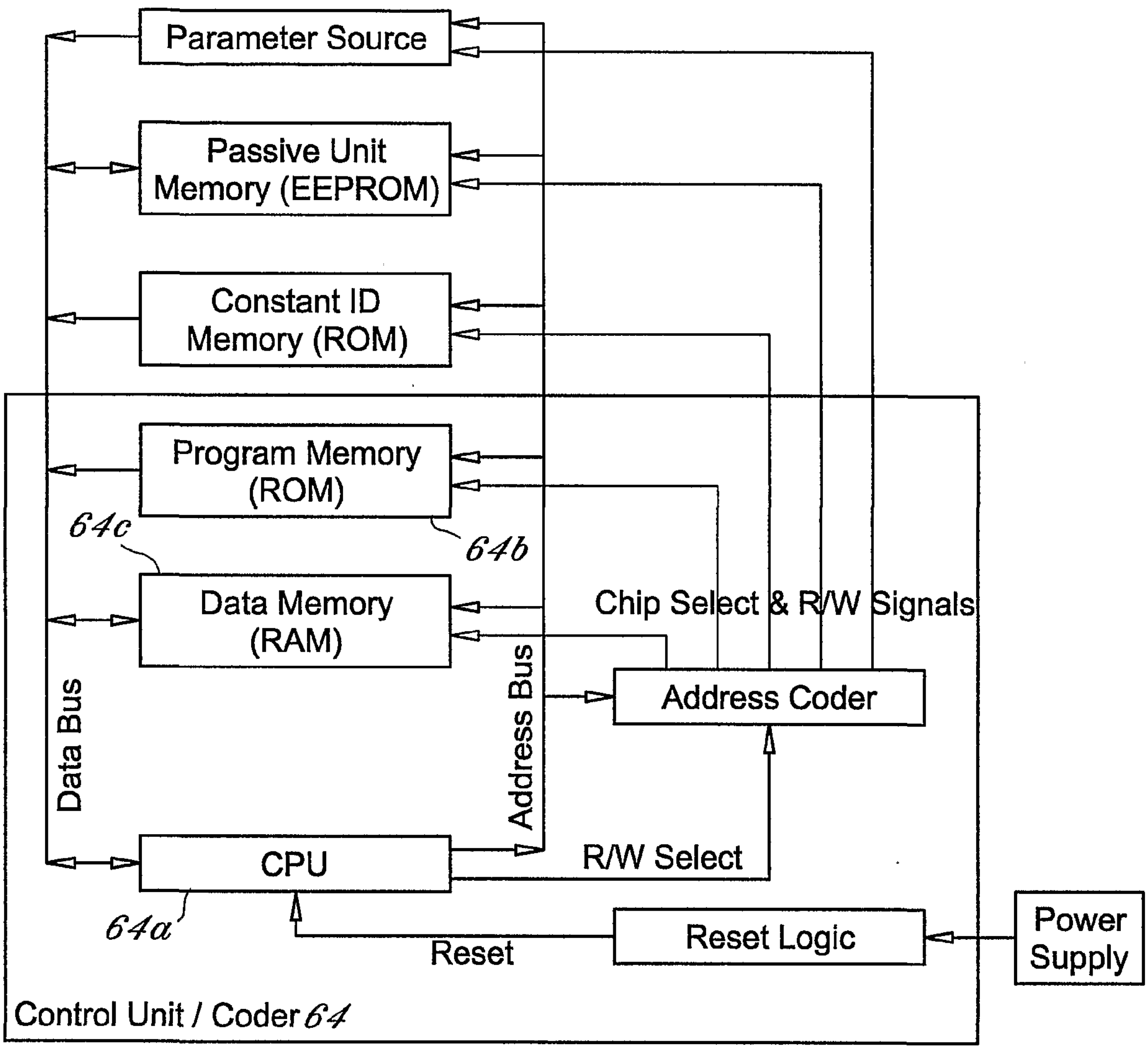
Parameter Source
Passive Unit Memory (EEPROM)
Constant ID Memory (ROM)
Program Memory (ROM)
64c
64b
Data Memory (RAM)
Chip Select & R/W Signals
Data Bus
Address Bus
Address Coder
CPU
R/W Select
64a
Reset
Reset Logic
Power Supply
Control Unit / Coder 64

Fig. 11

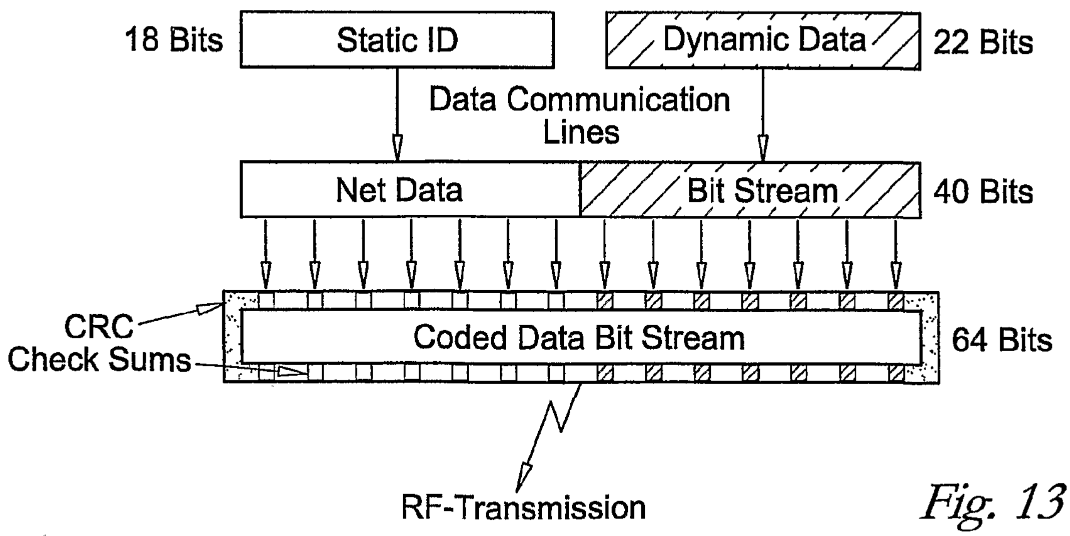
18 Bits
Static ID
Dynamic Data
22 Bits
Data Communication Lines
Net Data
Bit Stream
40 Bits
CRC Check Sums
Coded Data Bit Stream
64 Bits
RF-Transmission

Fig. 13

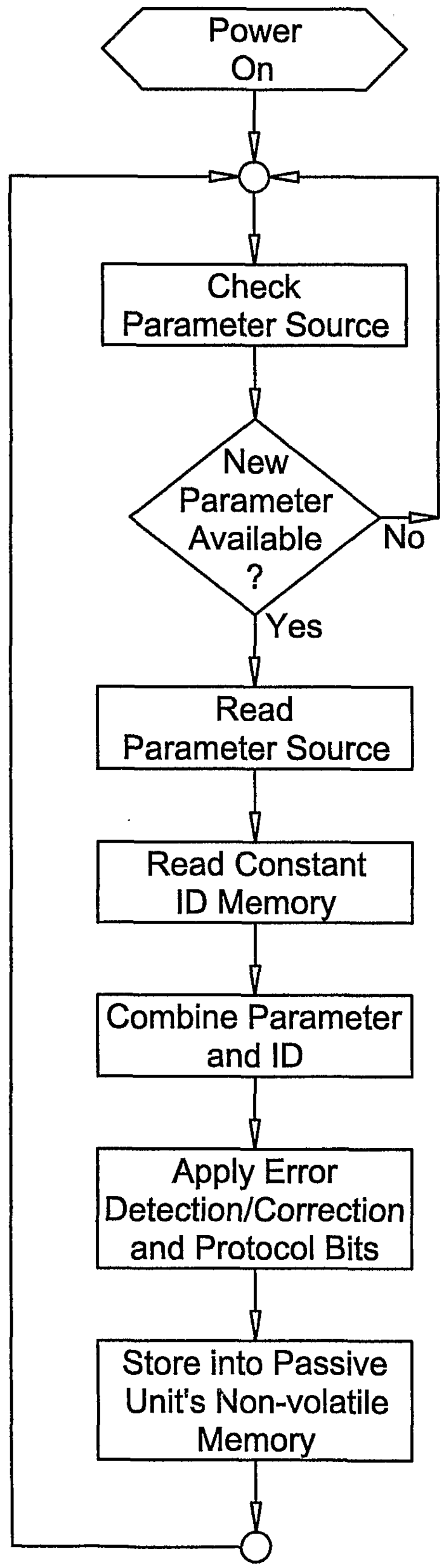
Power
On
Check
Parameter Source
New
Parameter
Available
?
No
Yes
Read
Parameter Source
Read Constant
ID Memory
Combine Parameter
and ID
Apply Error
Detection/Correction
and Protocol Bits
Store into Passive
Unit's Non-volatile
Memory

Fig. 12

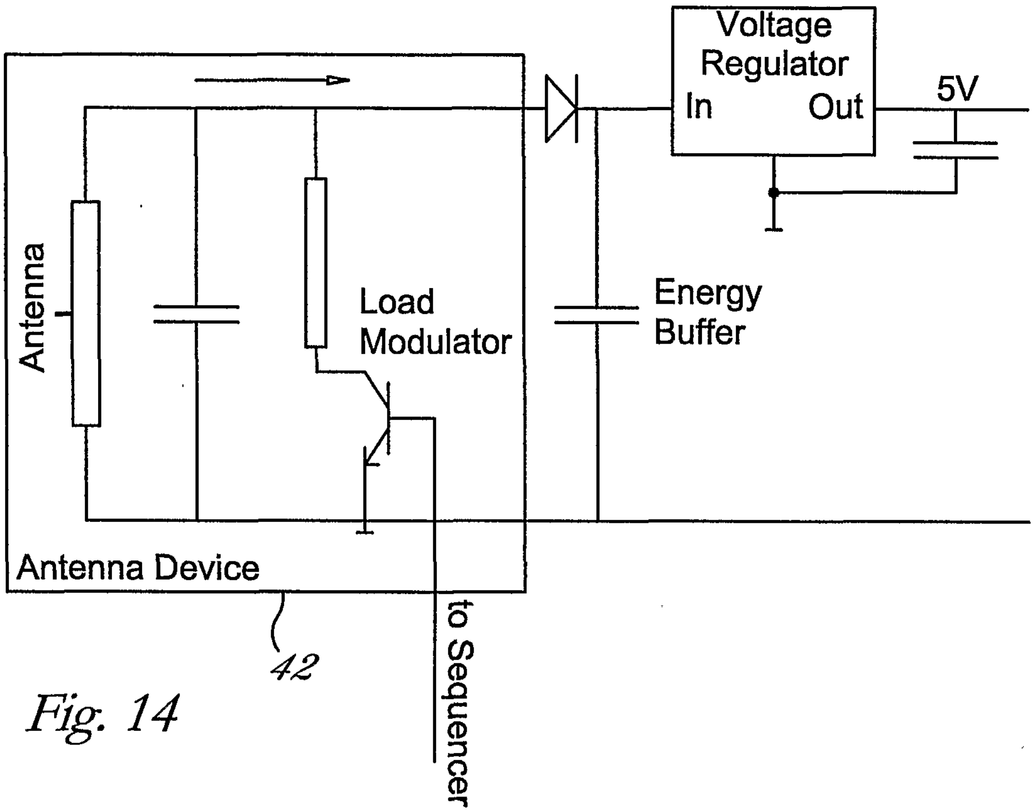
Voltage
Regulator
In
Out
5V
Antenna
Load
Modulator
Energy
Buffer
Antenna Device
42
to Sequencer

Fig. 14

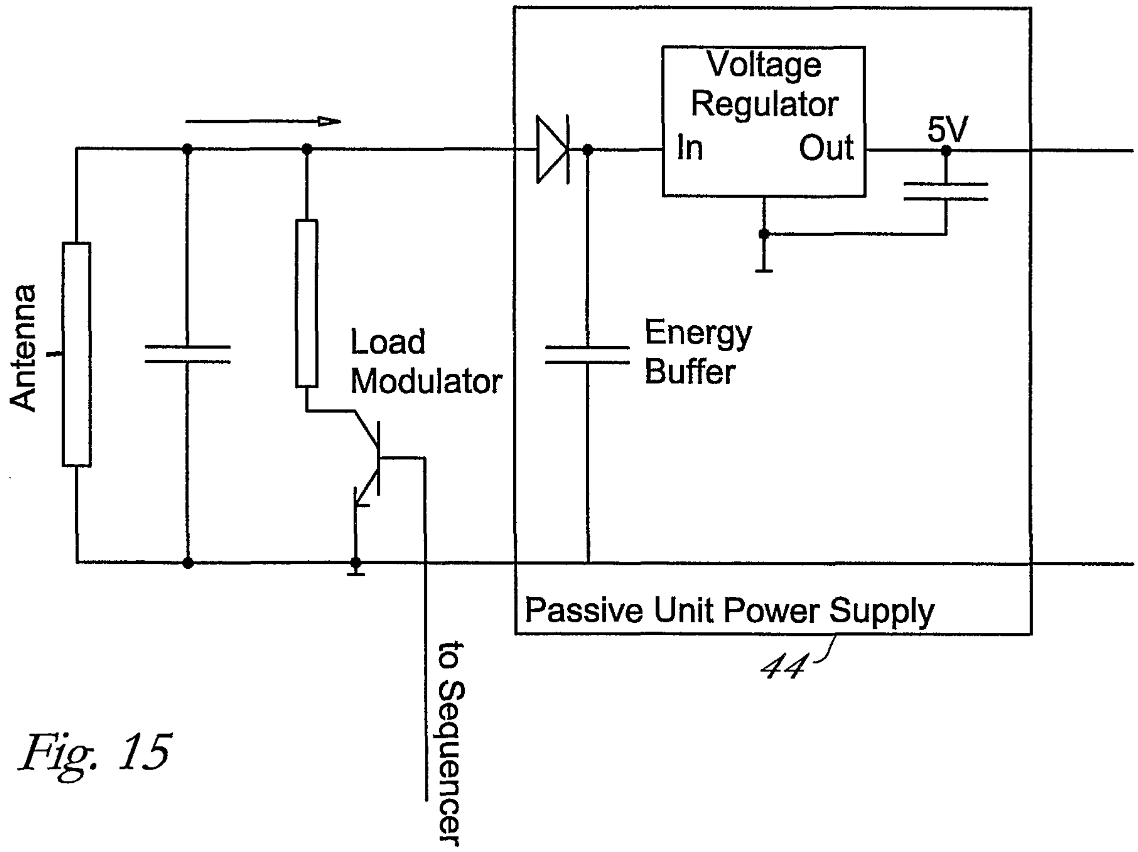
Voltage
Regulator
In
Out
5V
Antenna
Load
Modulator
Energy
Buffer
Passive Unit Power Supply
44
to Sequencer

Fig. 15

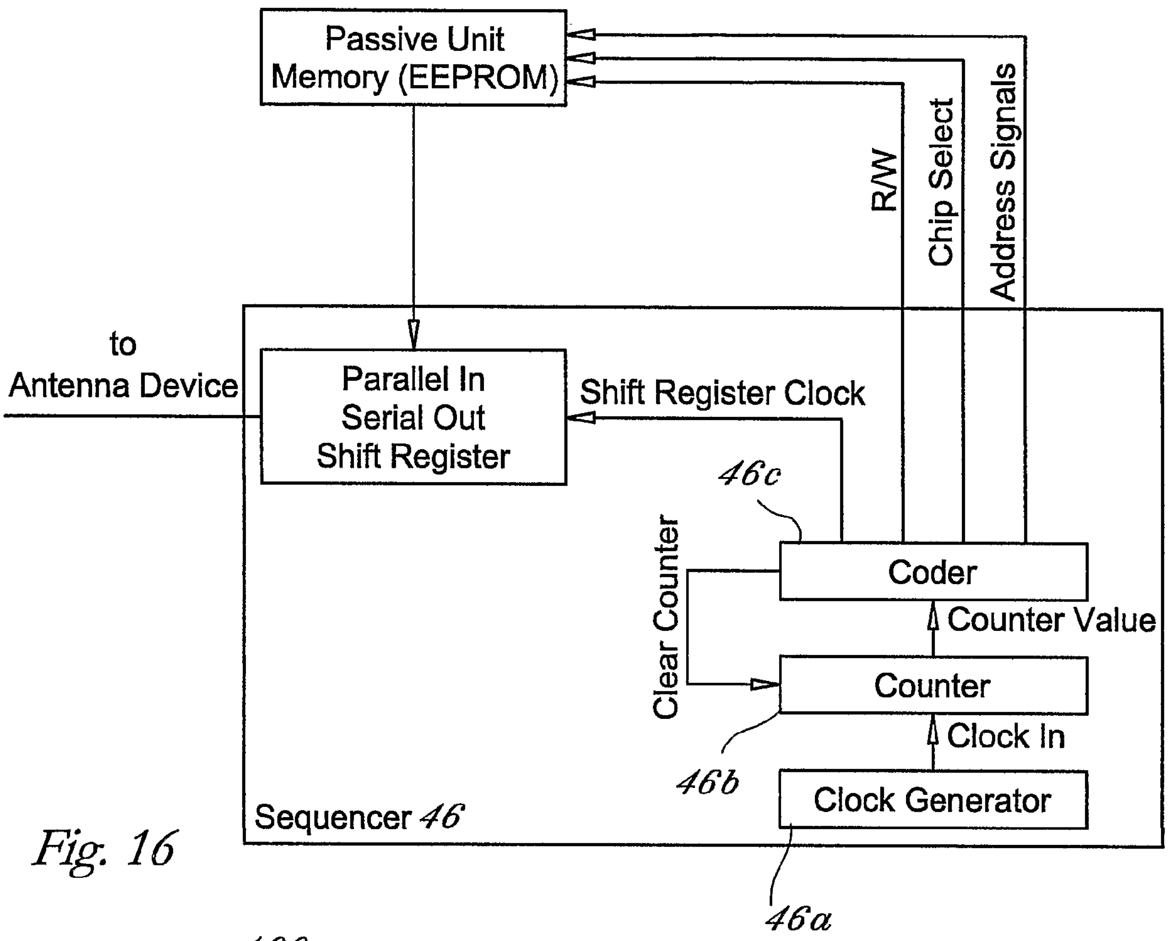
Passive Unit
Memory (EEPROM)
R/W
Chip Select
Address Signals
to
Antenna Device
Parallel In
Serial Out
Shift Register
Shift Register Clock
46c
Clear Counter
Coder
Counter Value
Counter
Clock In
46b
Clock Generator
Sequencer 46
46a

Fig. 16

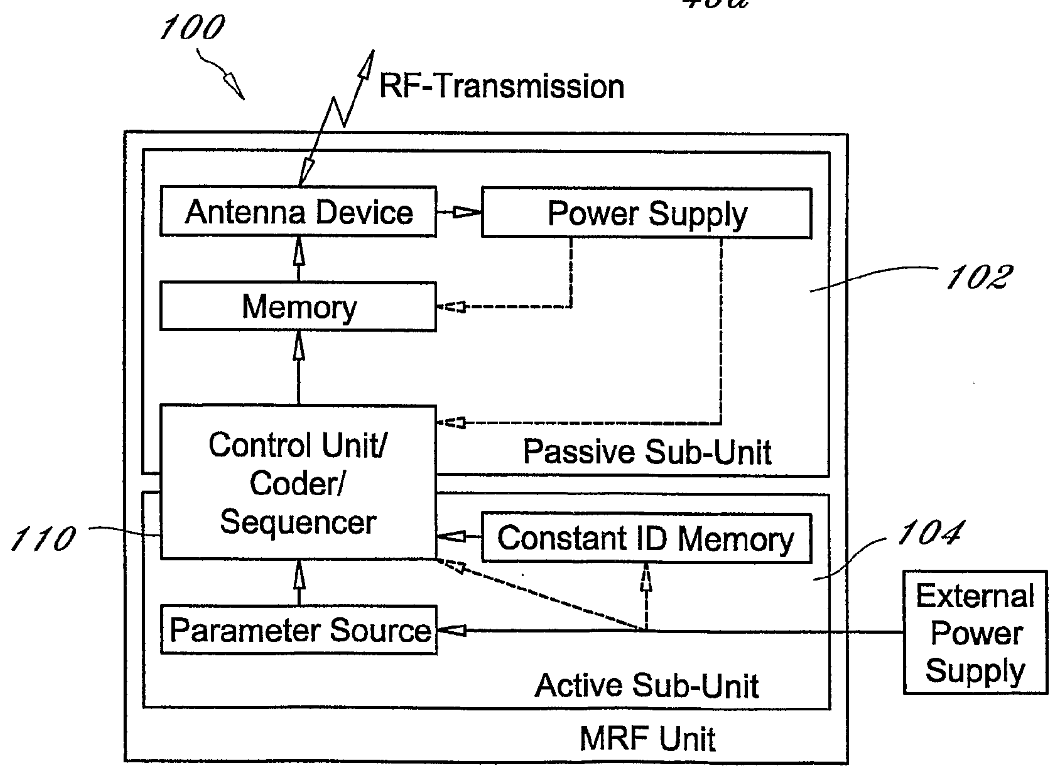
100
RF-Transmission
Antenna Device
Power Supply
Memory
102
Control Unit/
Coder/
Sequencer
Passive Sub-Unit
110
Constant ID Memory
104
External
Power
Supply
Parameter Source
Active Sub-Unit
MRF Unit

Fig. 17

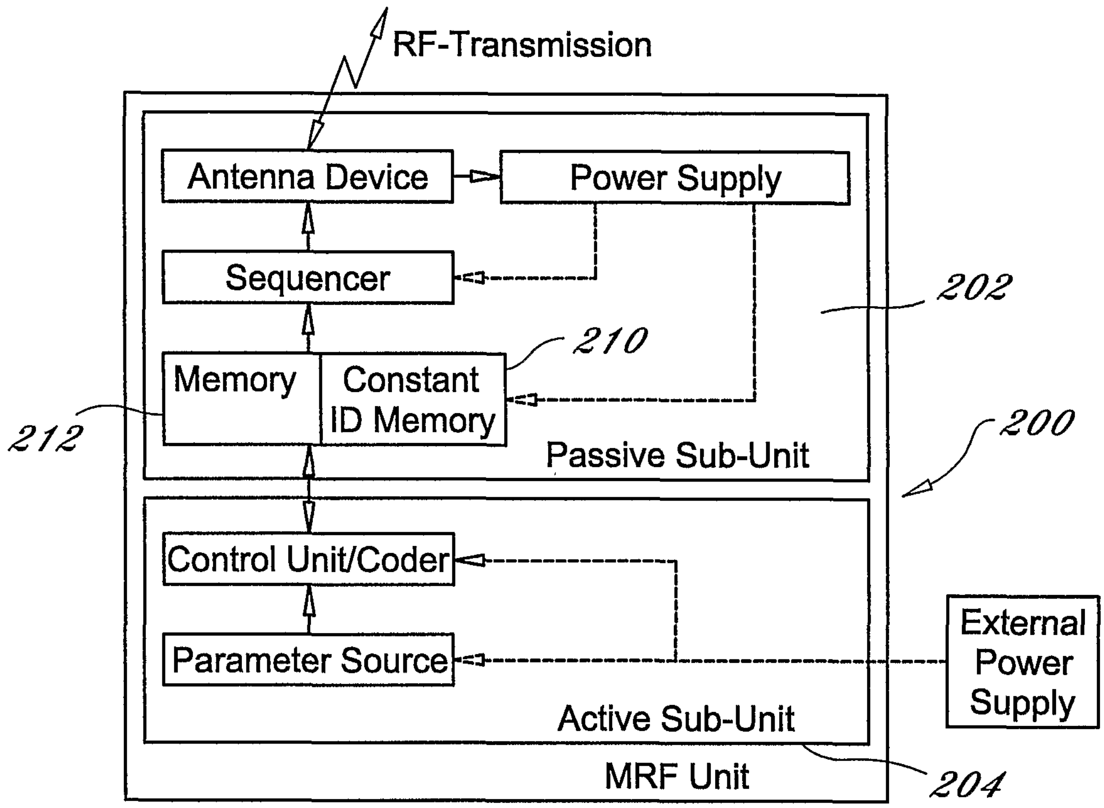
RF-Transmission
Antenna Device
Power Supply
Sequencer
202
210
Memory
Constant
ID Memory
212
200
Passive Sub-Unit
Control Unit/Coder
Parameter Source
External
Power
Supply
Active Sub-Unit
MRF Unit
204

Fig. 18

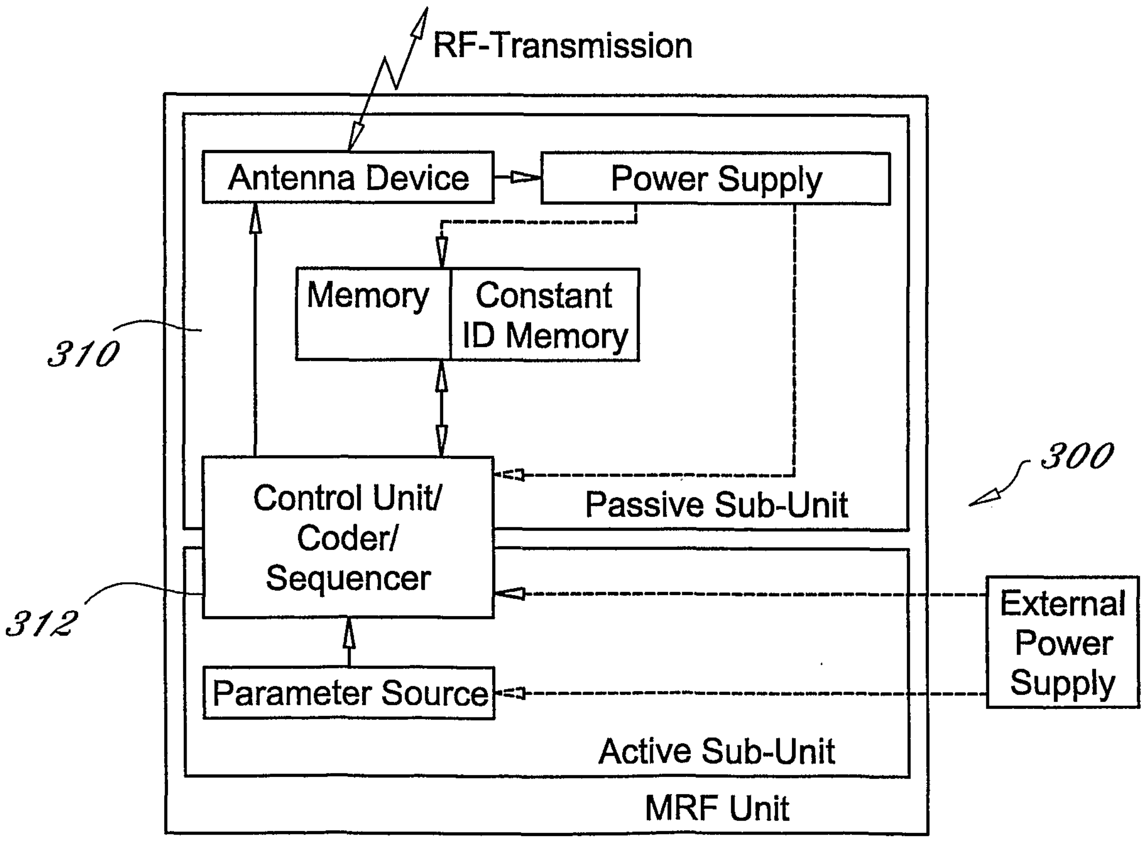
RF-Transmission
Antenna Device
Power Supply
Memory
Constant
ID Memory
310
300
Control Unit/
Coder/
Sequencer
Passive Sub-Unit
312
External
Power
Supply
Parameter Source
Active Sub-Unit
MRF Unit

Fig. 19

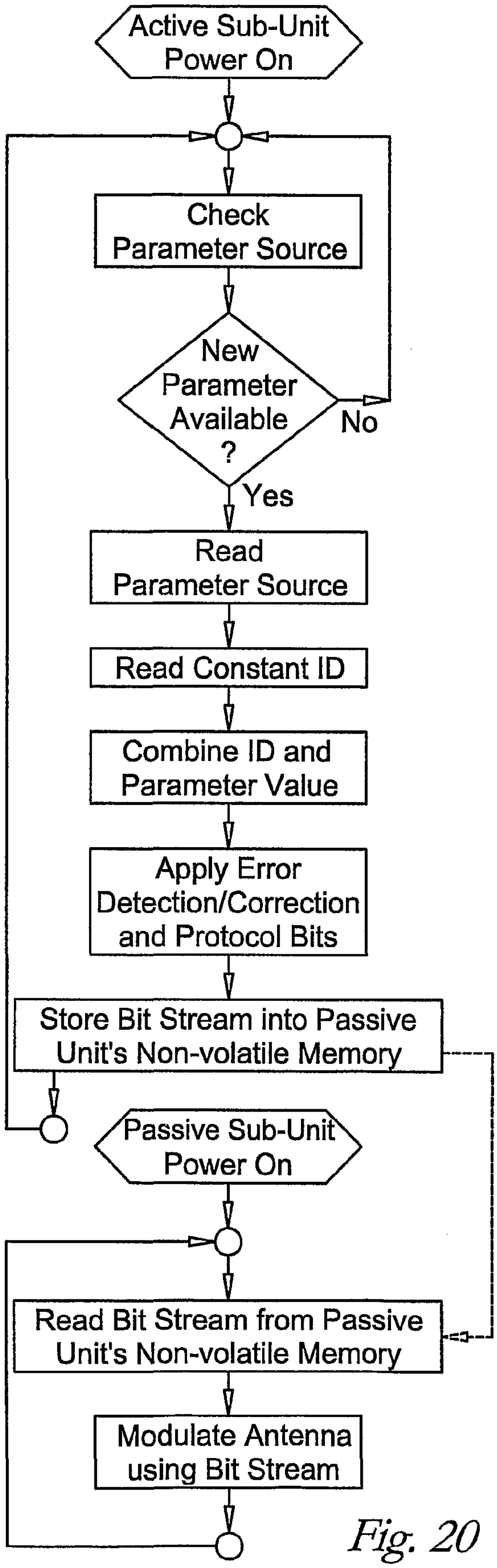
Active Sub-Unit Power On
Check Parameter Source
New Parameter Available ?
No
Yes
Read Parameter Source
Read Constant ID
Combine ID and Parameter Value
Apply Error Detection/Correction and Protocol Bits
Store Bit Stream into Passive Unit's Non-volatile Memory
Passive Sub-Unit Power On
Read Bit Stream from Passive Unit's Non-volatile Memory
Modulate Antenna using Bit Stream

Fig. 20

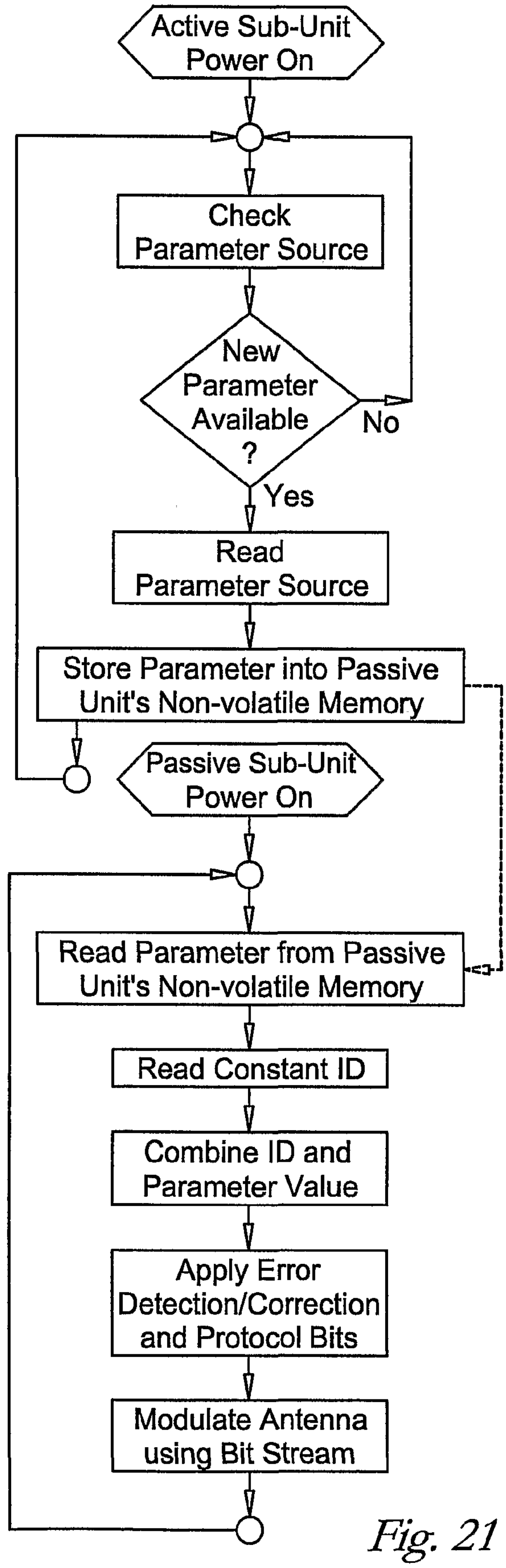
Active Sub-Unit Power On
Check Parameter Source
New Parameter Available ?
No
Yes
Read Parameter Source
Store Parameter into Passive Unit's Non-volatile Memory
Passive Sub-Unit Power On
Read Parameter from Passive Unit's Non-volatile Memory
Read Constant ID
Combine ID and Parameter Value
Apply Error Detection/Correction and Protocol Bits
Modulate Antenna using Bit Stream

Fig. 21

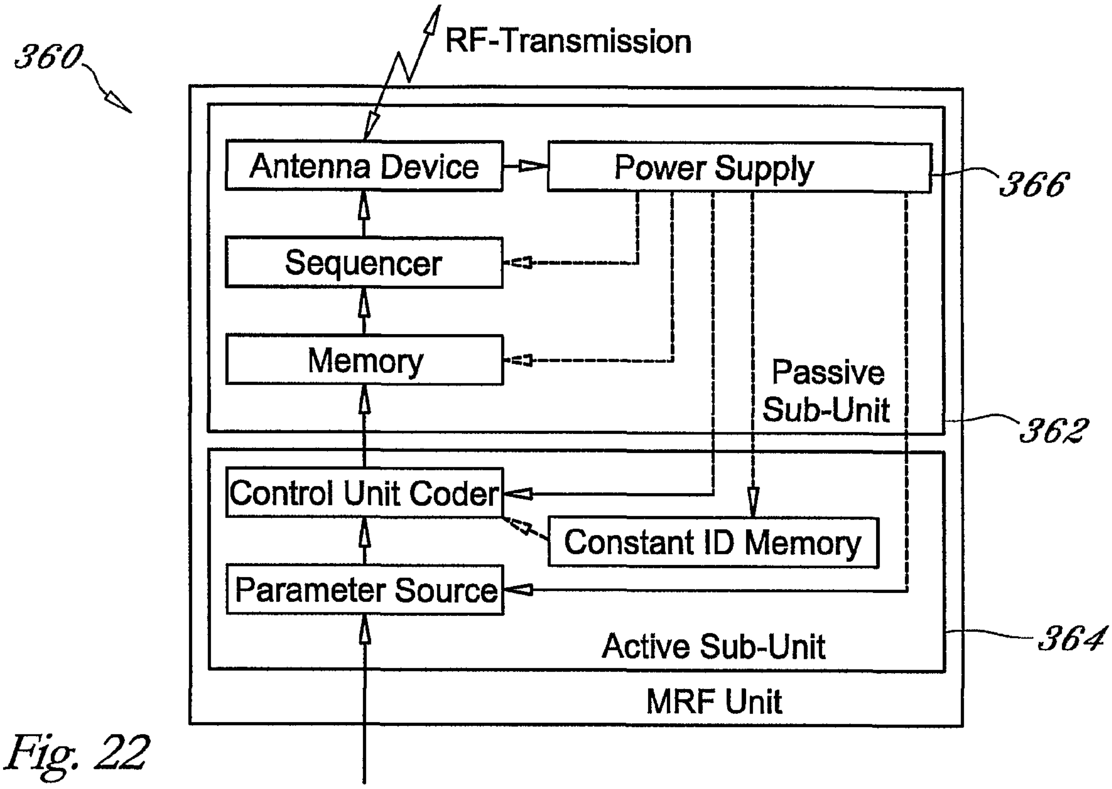

Fig. 22

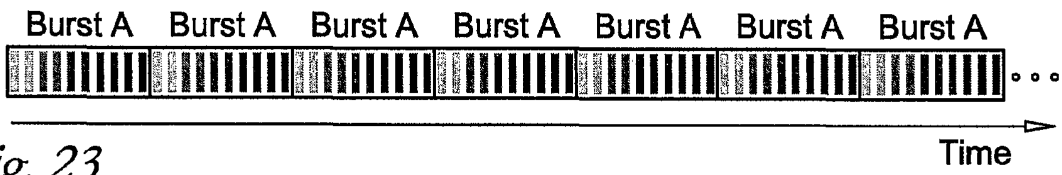

Fig. 23

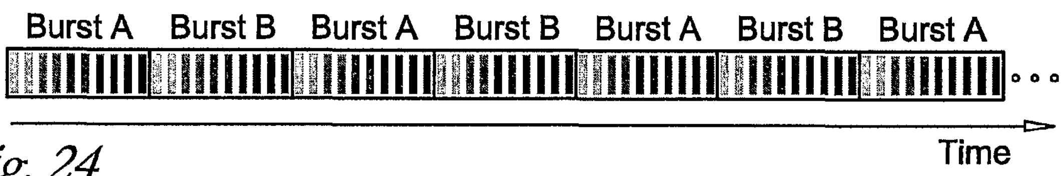

Fig. 24

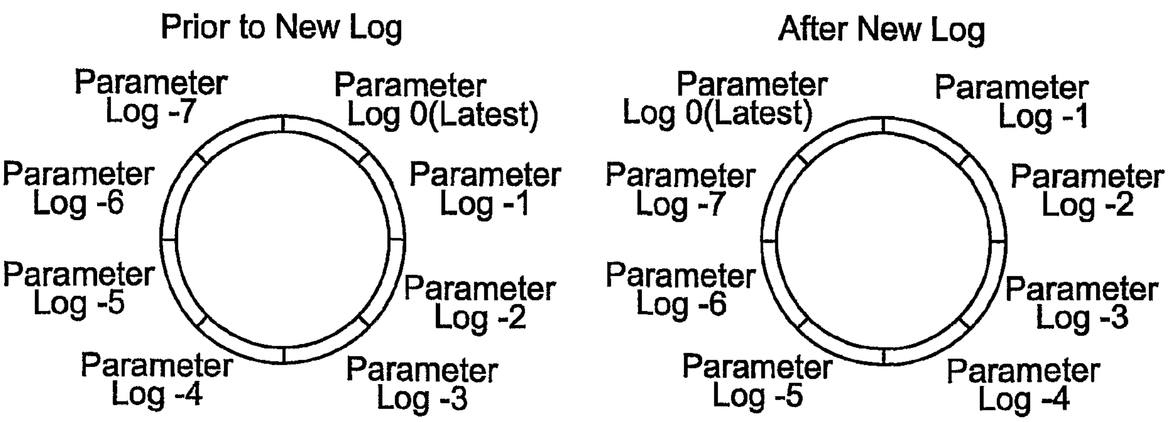

Fig. 25

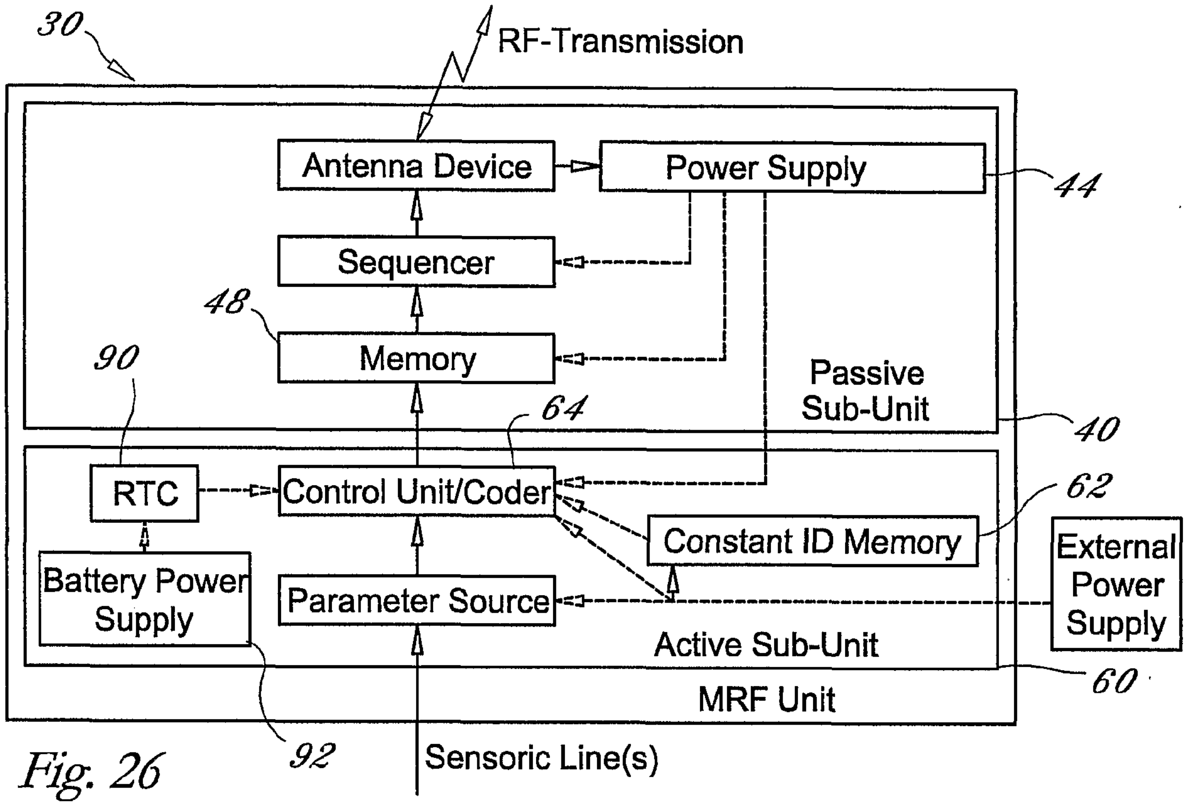

Fig. 26

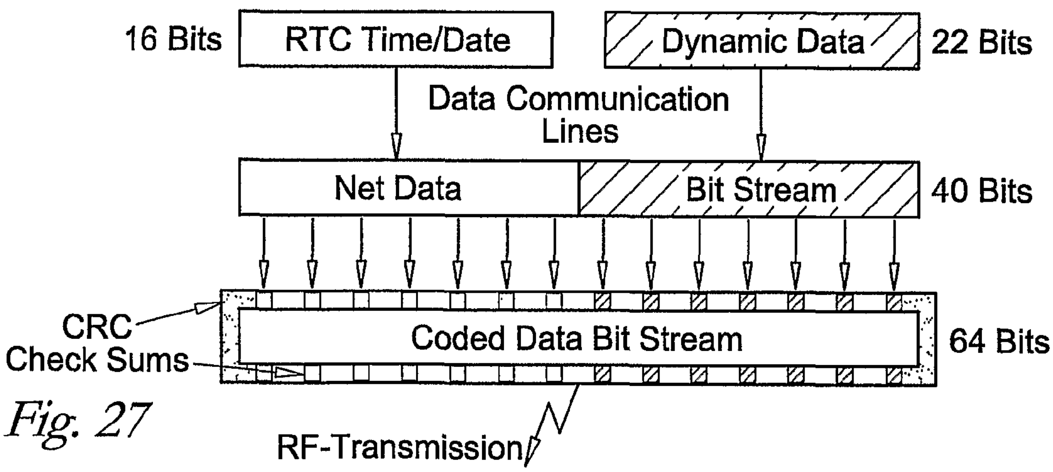

Fig. 27

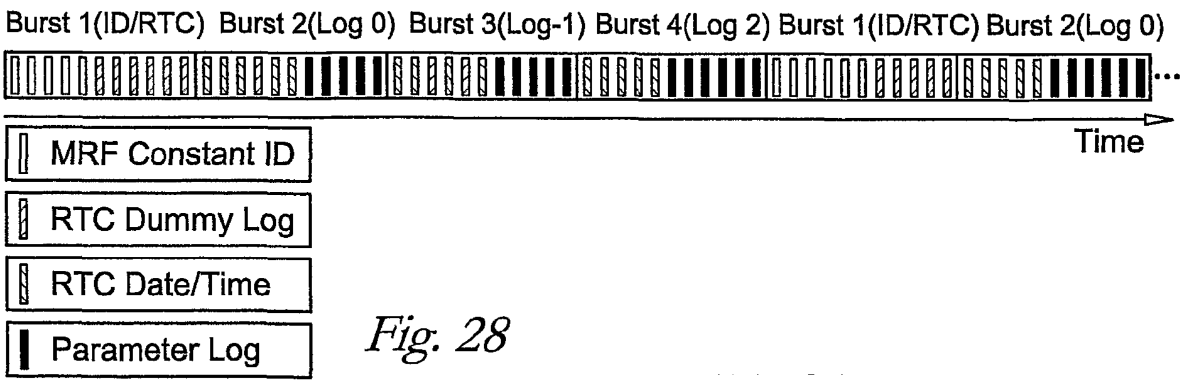

Fig. 28

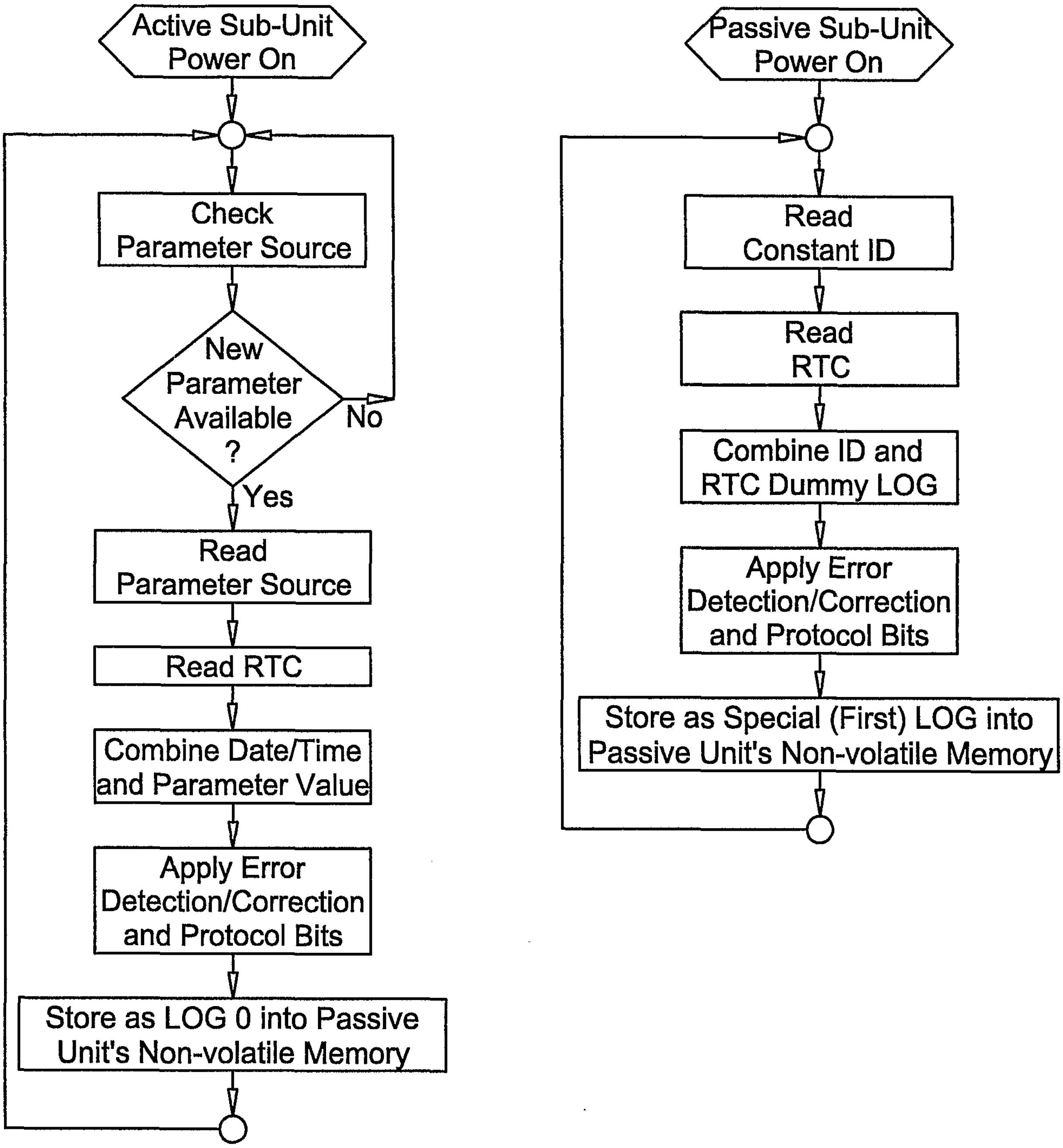
Active Sub-Unit Power On
Check Parameter Source
New Parameter Available ?
No
Yes
Read Parameter Source
Read RTC
Combine Date/Time and Parameter Value
Apply Error Detection/Correction and Protocol Bits
Store as LOG 0 into Passive Unit's Non-volatile Memory
Passive Sub-Unit Power On
Read Constant ID
Read RTC
Combine ID and RTC Dummy LOG
Apply Error Detection/Correction and Protocol Bits
Store as Special (First) LOG into Passive Unit's Non-volatile Memory

Fig. 29

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/13812

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) :Please See Extra Sheet.
US CL :Please See Extra Sheet.
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)

U.S. : 340/572.7, 571, 539, 10.41, 573.4, 10.5, 870.11, 870.16; 235/440, 472.02, 419; 382/313, 305; 374/102

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 practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ---- Y	UK 2,308,947 A (HOWELL et al) 07 SEPTEMBER 1997, ALL	1-4 ------ 5-29
Y	US 4,972,099 A (AMANO et al) 20 NOVEMBER 1990, ALL	5-29
A	US 5,028,918 A (GILES et al) 02 JULY 1991, ALL	1-29
A	US 4,092,524 A (MORENO) 30 MAY 1978, ALL	1-29
A	US 4,952,928 A (CARROLL et al) 28 AUGUST 1990, ALL	1-29
Y	US 5,465,618 A (YASUI et al) 14 NOVEMBER 1995, ALL	15-16

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"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	Date of mailing of the international search report
19 JUNE 2001	19 OCT 2001

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	ALBERT WONG
Facsimile No. (703) 305-3230	Telephone No. (703) 305-8884

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,795,069 A (MATTES) 18 AUGUST 1998, ALL	15-16
A	US 4,467,434 A (HURLEY et al) 21 AUGUST 1984, ALL	17-18
A	US 5,473,322 A (CARNEY) 05 DECEMBER 1995, ALL	17-18
A	US 5,537,029 A (HEMMINGER et al) 16 JULY 1996, ALL	17-18

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/13812

A. CLASSIFICATION OF SUBJECT MATTER:
IPC (7):

G08B 13/14, 23/00, 21/00; G08C 19/10, 19/04; H04Q 7/00, 5/22; G06C 15/00; G06F 03/08; G06K 9/22, 9/54, 9/60

A. CLASSIFICATION OF SUBJECT MATTER:
US CL :

340/572.7, 571, 539, 10.41, 573.4, 10.5, 870.11, 870.16; 235/440, 472.02, 419; 382/313, 305; 374/102