US 20070077896A1

(19) United States
(12) Patent Application Publication
Ho et al.
(10) Pub. No.: US 2007/0077896 A1
(43) Pub. Date: Apr. 5, 2007

(54) TRANSCEIVER REDUNDANCY IN AN ELECTRONIC TOLL COLLECTION SYSTEM

(76) Inventors: **Thua Van Ho**, Mississauga (CA); **Daniel Terrier**, Toronto (CA); **Roger Tong**, Oakville (CA); **Wai-Cheung Tang**, Mannheim (CA)

Correspondence Address:
HANLEY, FLIGHT & ZIMMERMAN, LLC
150 S. WACKER DRIVE
SUITE 2100
CHICAGO, IL 60606 (US)

(21) Appl. No.: **11/534,052**

(22) Filed: **Sep. 21, 2006**

Related U.S. Application Data

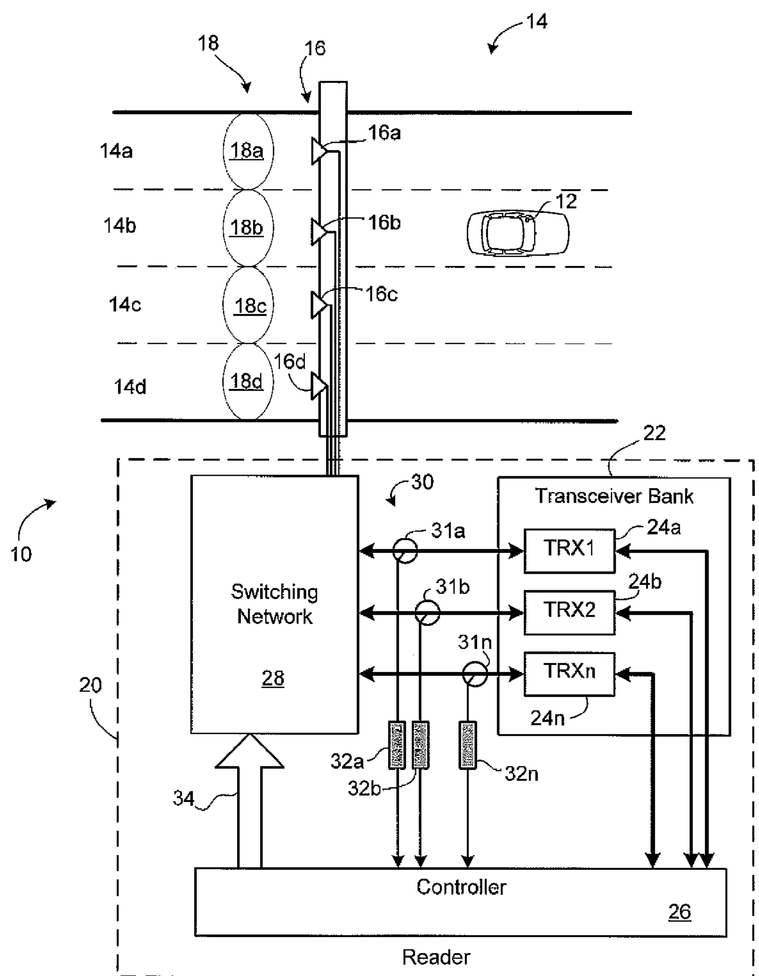
(60) Provisional application No. 60/718,742, filed on Sep. 21, 2005. Provisional application No. 60/718,743, filed on Sep. 21, 2005. Provisional application No. 60/718,744, filed on Sep. 21, 2005.

Publication Classification

(51) **Int. Cl.**
H04B 1/44 (2006.01)
(52) **U.S. Cl.** **455/78**

(57) **ABSTRACT**

An electronic toll collection system wherein the reader includes a switching network and a plurality of transceivers operating under the control of a controller. The reader further includes failure detection circuitry for determining whether any of the transceivers have failed based upon the RF outputs of the transceivers. If the controller determines that a transceiver has failed, then it alters the switching pattern such that the switching network excludes the failed transceiver from being connected to the antennas. The reader thereby provides for adaptive RF channel assignment, as the particular transceiver used to excite a particular antenna may be dynamically altered, and the provision of at least two transceivers in the reader ensures transceiver redundancy.



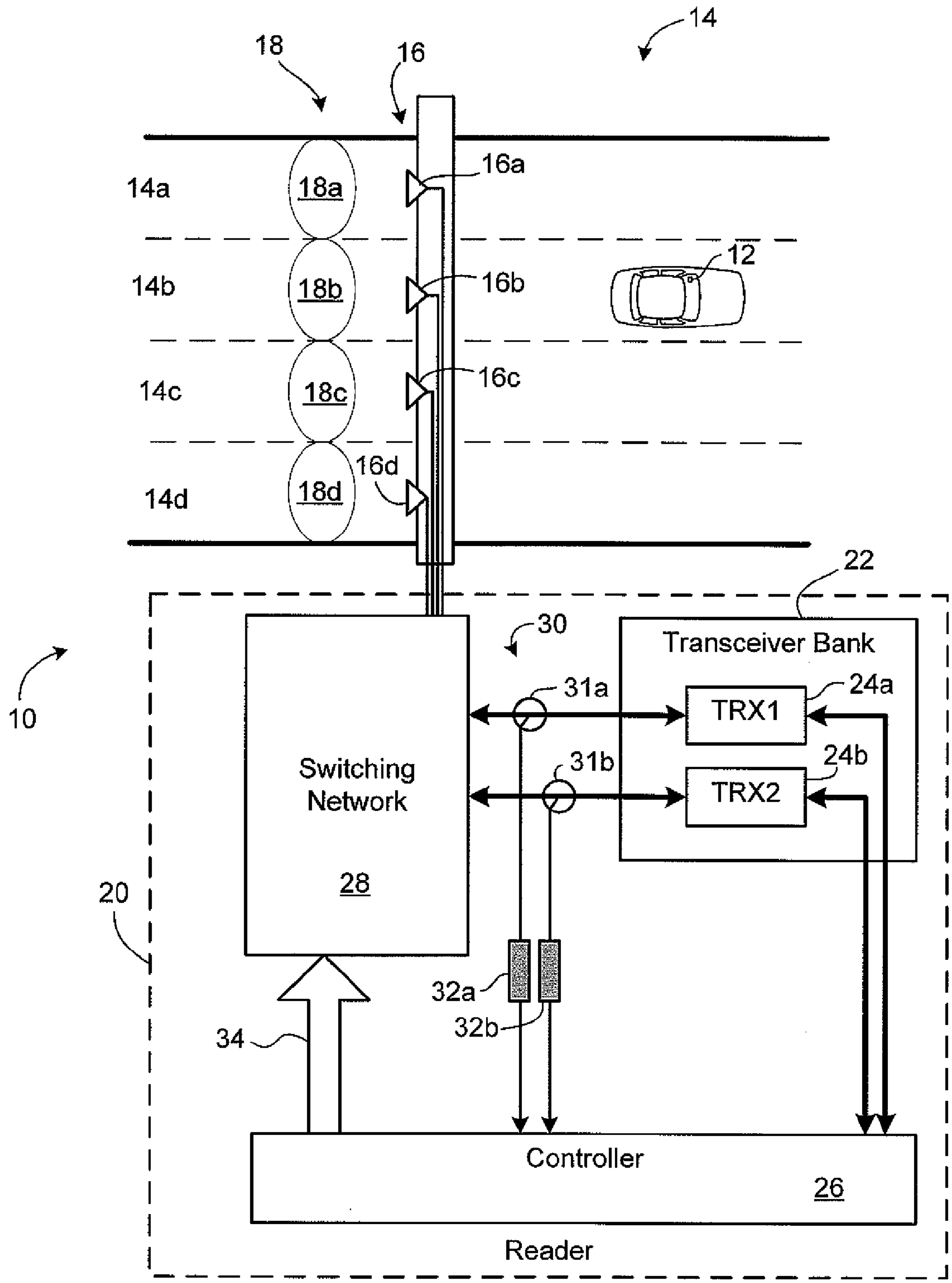

14
18
16
16a
14a
18a
12
14b
18b
16b
14c
18c
16c
16d
14d
18d
22
10
30
Transceiver Bank
31a
24a
TRX1
Switching
Network
31b
24b
TRX2
20
28
32a
34
32b
Controller
26
Reader

FIG. 1

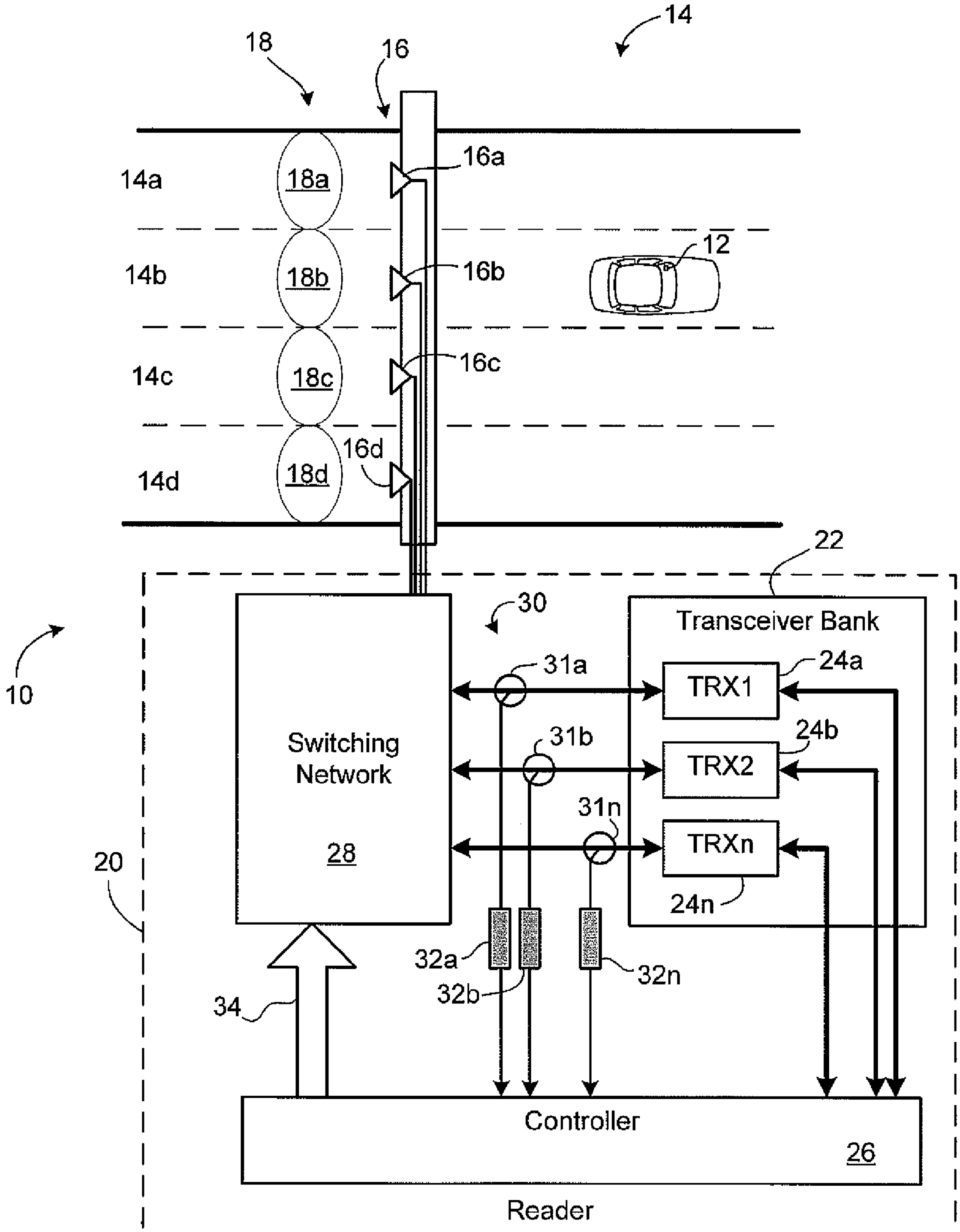

14
18
16
14a
18a
16a
14b
18b
16b
12
14c
18c
16c
14d
18d
16d
22
30
Transceiver Bank
31a
TRX1
24a
10
Switching
Network
31b
24b
TRX2
31n
28
TRXn
20
24n
32a
32b
32n
34
Controller
26
Reader

FIG. 2

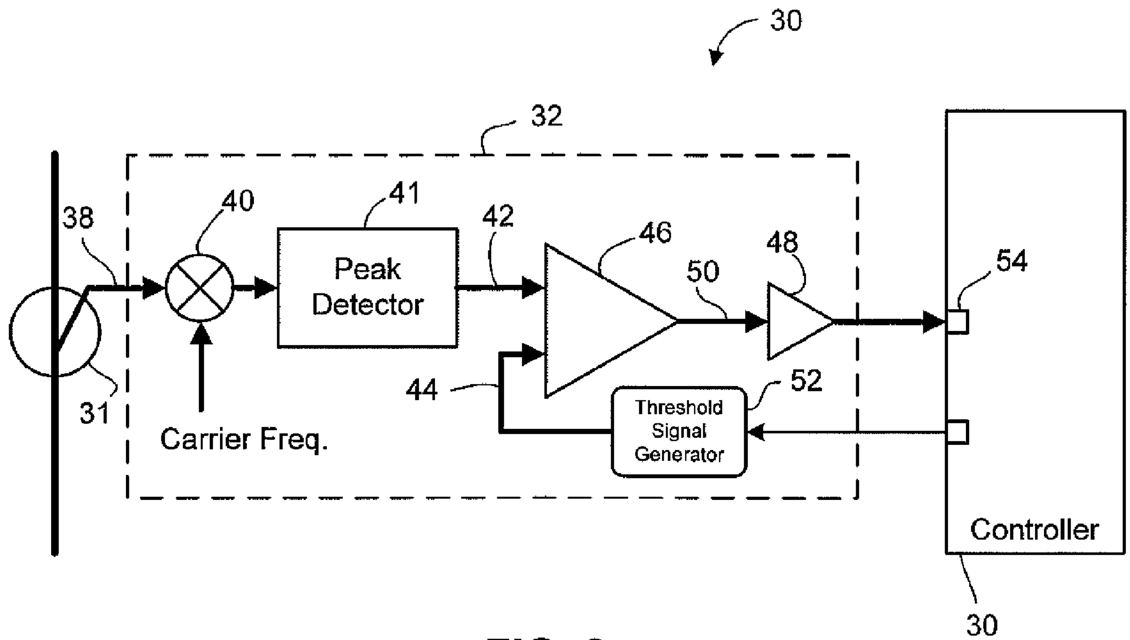

30
32
38
40
41
Peak
Detector
42
46
50
48
54
31
44
Carrier Freq.
Threshold
Signal
Generator
52
Controller
30

FIG. 3

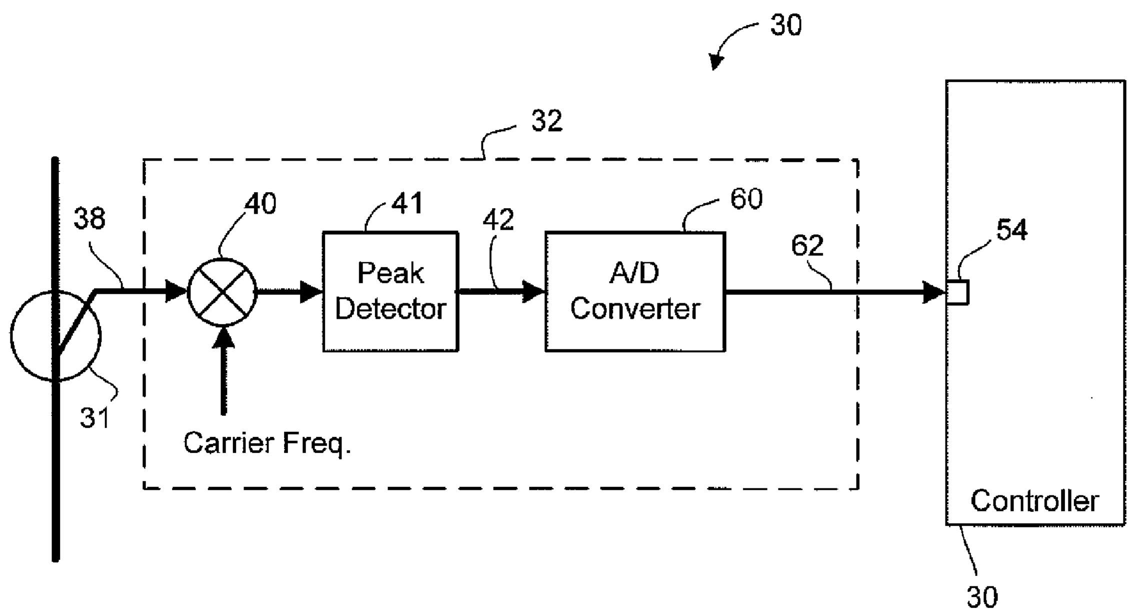

30
32
38
40
41
Peak
Detector
42
60
A/D
Converter
62
54
31
Carrier Freq.
Controller
30

FIG. 4

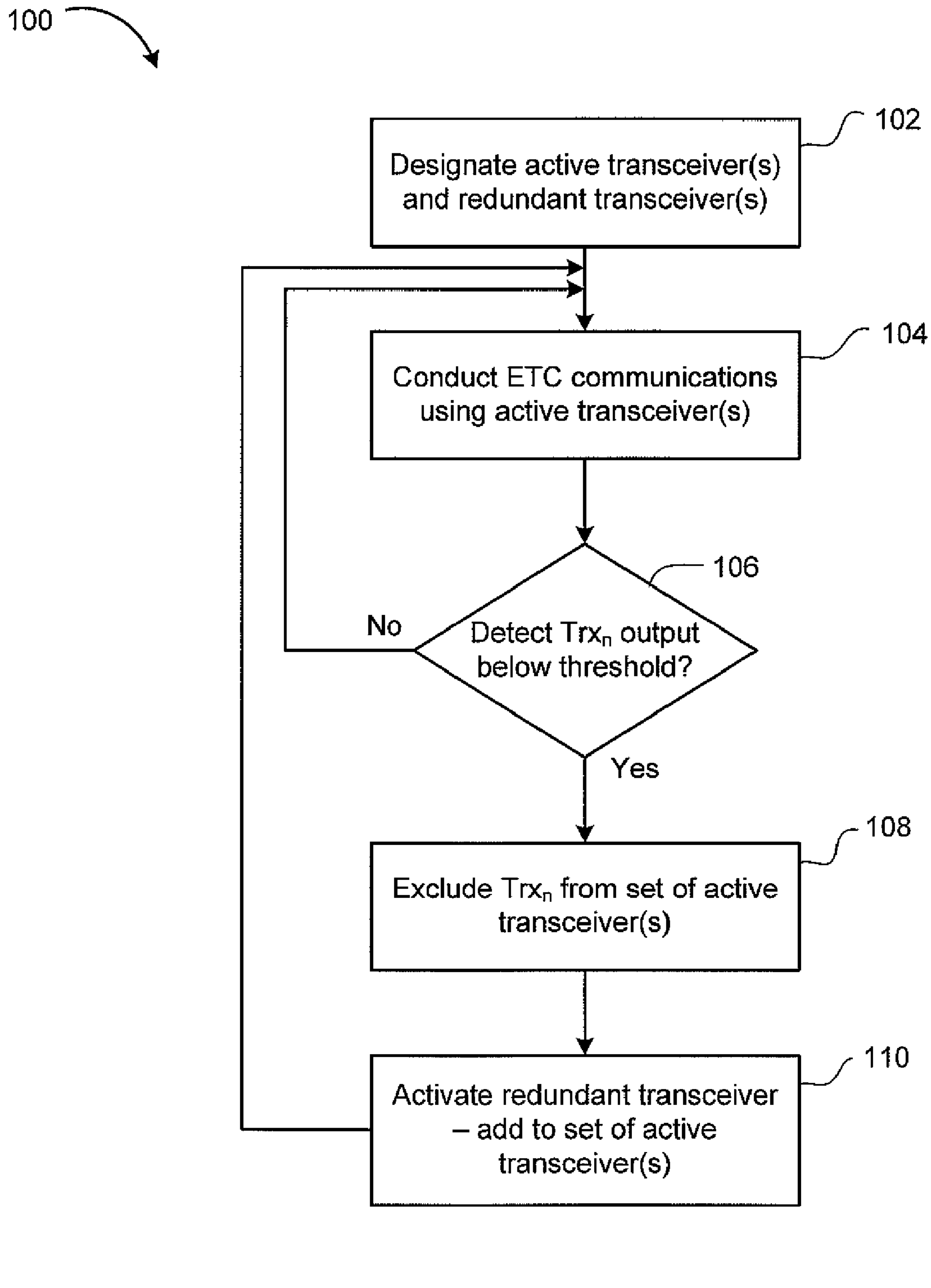

100
Designate active transceiver(s) and redundant transceiver(s)
102
Conduct ETC communications using active transceiver(s)
104
Detect Trx_n output below threshold?
106
No
Yes
Exclude Trx_n from set of active transceiver(s)
108
Activate redundant transceiver – add to set of active transceiver(s)
110

FIG. 5

TRANSCEIVER REDUNDANCY IN AN ELECTRONIC TOLL COLLECTION SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority to U.S. provisional patent application Ser. No. 60/718,742, U.S. provisional patent application Ser. No. 60/718,743, and U.S. provisional patent application Ser. No. 60/718,744, all filed Sep. 21, 2005.

FIELD OF THE INVENTION

[0002] The present invention relates to electronic toll collection systems and, in particular, an electronic toll collection system configured to detect transceiver failure and adaptively switch transceivers.

BACKGROUND OF THE INVENTION

[0003] Electronic toll collection systems conduct toll transactions electronically using RF communications between a vehicle-mounted transponder (a "tag") and a stationary toll plaza transceiver (a "reader"). An example of an electronic toll collection system is described in U.S. Pat. No. 6,661,352 issued Dec. 9, 2003 to Tiernay et al., and owned in common with the present application. The contents of U.S. Pat. No. 6,661,352 are hereby incorporated by reference.

[0004] In a typical electronic toll collection (ETC) system, a set of antennas are disposed to cover the roadway with overlapping coverage zones. Each antenna broadcasts a wakeup or trigger RF signal within its coverage zone. A tag on a vehicle passing through the coverage area or zone detects the wakeup or trigger signal and responds with its own RF signal. The tag responds by sending a response signal containing information stored in memory in the transponder, such as the transponder ID number. The response signal is received by the antenna.

[0005] The antennas operate under the control of a reader that typically uses time multiplexing to scan the roadway for transponders using each antenna in turn. When an antenna receives a response signal, the response signal is input to the reader, which may then conduct an electronic toll transaction, such as by debiting a user account associated with the transponder ID number. The reader may then cause the antenna to broadcast a programming RF signal to the tag. The programming signal provides the tag with updated information for storage in its memory. It may, for example, provide the tag with a new account balance.

[0006] In one electronic toll collection system, the reader may include a single RF transceiver, a multiplexer, and a controller. The controller controls operation of the RF transceiver and conducts the toll transactions. The controller may cause the multiplexer to selectively connect the RF transceiver to each of the antennas in turn, thereby implementing time multiplexed scanning. It will be appreciated that failure of the RF transceiver results in a total loss of coverage.

[0007] In another electronic toll collection system, the reader may include an RF transceiver for each antenna. In this case, a failure of an RF transceiver causes a loss of coverage corresponding to the coverage area of the antenna connected to the failed transceiver. This may mean that a lane within the roadway has no effective coverage. This loss of coverage may be difficult to detect, since the majority of the system remains operational. Accordingly, the defect may persist for days without discovery. This is especially so in cases where there is overlapping coverage, such as where a lane is partly served by a center-lane antenna and mid-lane antennas on either side.

[0008] It would be advantageous to have an improved electronic toll collection system.

SUMMARY OF THE INVENTION

[0009] The present invention provides for an electronic toll collection system wherein the reader includes a switching network and a plurality of transceivers operating under the control of a controller. The reader further includes failure detection circuitry for determining whether any of the transceivers have failed based upon the RF outputs of the transceivers. If the controller determines that a transceiver has failed, then it alters the switching pattern such that the switching network excludes the failed transceiver from being connected to the antennas. The reader thereby provides for adaptive RF channel assignment, as the particular transceiver used to excite a particular antenna may be dynamically altered, and the provision of at least two transceivers in the reader ensures transceiver redundancy.

[0010] In one aspect, the present application provides an electronic toll collection system for conducting toll transactions with vehicle-mounted transponders travelling in a multi-lane roadway. The electronic toll collection system includes one or more antennas for engaging in RF communications with transponders, each antenna defining a capture zone in a portion of at least one lane of the multi-lane roadway, and two or more RF transceivers, each RF transceiver having an RF port. It also includes a switching network connected to the antennas and to the RF ports of the transceivers, the switching network selectively connecting at least one of the transceivers to at least one of the antennas, and a controller for controlling the switching network and the transceivers. The system further includes failure detection circuitry connected to the RF ports of the transceivers for detecting whether any of the transceivers output an RF signal having a power level below a threshold level, the failure detection circuitry providing a result signal to the controller. The controller is configured to control the switching network to connect the antennas to the transceivers in accordance with a scanning pattern, and the controller is configured to cause the switching network exclude one of the transceivers if the result signal from the failure detection circuitry indicates a failure in the one of the transceivers.

[0011] In another aspect, the present application provides a method for adaptively switching transceiver usage in an electronic toll collection system used to conduct toll transactions with vehicle-mounted transponders travelling in a multi-lane roadway. The system includes one or more antennas for engaging in RF communications with transponders, two or more RF transceivers wherein each RF transceiver has an RF port, and a switching network connected to the antennas and to the RF ports of the transceivers, the switching network selectively connecting at least one of the transceivers to at least one of the antennas under control of a controller. The system further includes failure detection circuitry connected to the RF ports for detecting whether any of the transceivers output an RF signal having a power level below a threshold level, the failure detection circuitry providing an output signal to the controller. The method includes steps of designating a set of active transceivers, wherein the set of active transceivers includes at least one of the transceivers, conducting RF communications through one of the antennas using the set of active transceivers, determining that the RF signal from one of the active transceivers falls below a threshold power level, and excluding the one of the active transceivers from the set of active transceivers.

[0012] In yet another aspect, the present application provides an electronic toll collection system for conducting toll transactions with vehicle-mounted transponders travelling in a multi-lane roadway. The electronic toll collection system includes one or more antennas for engaging in RF communications with transponders, two or more RF transceivers each having an RF port, controller means for controlling the transceivers to implement a scanning pattern, switching means connected to the antennas and to the RF ports of the transceivers for selectively connecting at least one of the transceivers to at least one of the antennas under control of the controller means, and failure detection means connected to the RF ports of the transceivers for detecting whether any of the transceivers output an RF signal having a power level below a threshold level, the failure detection means providing a result signal to the controller means. The controller means further includes means for causing the switching means to connect the antennas to the transceivers in accordance with a scanning pattern, and the controller means includes means for causing the switching network exclude one of the transceivers if the result signal from the failure detection means indicates a failure in the one of the transceivers.

[0013] Other aspects and features of the present invention will be apparent to those of ordinary skill in the art from a review of the following detailed description when considered in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Reference will now be made, by way of example, to the accompanying drawings which show an embodiment of the present invention, and in which:

[0015] FIG. **1** shows a block diagram of an embodiment of an electronic toll collection system.

[0016] FIG. **2** shows a block diagram of another embodiment of an electronic toll collection system.

[0017] FIG. **3** diagrammatically shows an embodiment of failure detection circuitry from the electronic toll collection systems of FIGS. **1** and **2**.

[0018] FIG. **4** diagrammatically shows another embodiment of the failure detection circuitry.

[0019] FIG. **5** shows, in flowchart form, a method for adaptively switching transceiver usage in an electronic toll collection system.

[0020] Similar reference numerals are used in different figures to denote similar components.

DESCRIPTION OF SPECIFIC EMBODIMENTS

[0021] Reference is first made to FIGS. **1** and **2**, which show block diagrams of embodiments of an electronic toll collection system **10**. The system **10** operates to send and receive RF communications with vehicle-borne transponders **12**. In some embodiments, the system **10** is associated with a gated toll plaza. In some other embodiments, the system **10** is associated with an open-road toll processing zone. Other applications for the system **10** will be appreciated by those skilled in the art.

[0022] In the embodiments shown in FIGS. **1** and **2**, the system **10** is associated with a multi-lane roadway **14**. Individual lanes are shown as lanes **14***a*, **14***b*, **14***c*, and **14***d*.

[0023] The system **10** includes a set of antennas **16** (shown individually as **16***a*, **16***b*, **16***c*, and **16***d*). FIG. **1** shows that each antenna **16** is associated with a laneway. In particular, each antenna **16** is a directional antenna having a beam path that defines an antenna-specific capture zone **18** within the roadway **14**. The antennas **16** may, in some embodiments, be mounted to an overhead gantry or other structure. In many embodiments, the antennas **16** may be positioned such that their respective capture zones **18** span the width of the roadway **14** to ensure total coverage of all lanes of traffic.

[0024] It will be appreciated that there may be more antennas **16** or fewer antennas **16** than lanes in the roadway **14**. In one embodiment, midpoint or mid-lane antennas are also deployed defining a capture zone roughly centered at the midpoint between lanes. The mid-lane antennas provide overlapping coverage with the center-lane antennas **16** and may be useful in determining lane position of a transponder **12** within the roadway **14**. Other configurations of the antennas **16** will be appreciated by those skilled in the art.

[0025] The antennas **16** are connected to a roadside reader **20**. The roadside reader **20** excites each antenna **16** so as to induce propagation of an RF signal in the associated capture zone **18**. The antenna **16** receives incoming RF signals, which are input to the reader **30**. The incoming RF signals include transmissions from any active transponders within the capture zone **18**. It will be appreciated that the electronic toll collection system **10** may be based upon one or more pre-defined communications protocols and may involve the use of active or backscatter transponders.

[0026] The pre-defined communications protocols used in the system **10** include propagation of a trigger signal or wake-up signal by the antennas **16** in their respective capture zones **18**. Any transponder **12** within a particular capture zone **18** may respond by transmitting a response signal, which is received by the antenna **16** and input to the reader **20**.

[0027] In many embodiments, the reader **20** employs a time multiplexed scan, whereby each antenna **16** is assigned a time slot within which the antenna **16** broadcasts its trigger signal and awaits a response, if any. In the embodiments depicted in FIGS. **1** and **2**, the protocol may provide for four time slots during which each antenna is sequentially used to poll for transponders **12** in its respective capture zone **18**.

[0028] The roadside reader **20** includes a transceiver bank **22** and a controller **26**. The transceiver bank **22** contains two or more transceivers **24**. In FIG. **1**, the transceiver bank **22** includes a first transceiver **24***a* and a second transceiver **24***b*. FIG. **2** presents the more general case of n transceivers. The transceivers **24** are configured to modulate signals from the controller **26** for transmission as RF signals over the antennas **16**, and to de-modulate RF signals received by the antennas **16** into a form suitable for use by the controller **26**. In this regard, the reader **20** employs hardware and signal processing techniques that will be well understood by those skilled in the art. The controller **26** may include a programmable processing unit, volatile and non-volatile memory storing instructions and data necessary for the operation of the controller **26**, and communications interfaces to permit the controller **26** to communicate with the transceivers **24**.

[**0029**] The transceivers **24** may include one or more operating transceivers and one or more redundant transceivers. Rather than providing a dedicated transceiver for each antenna supplemented by a redundant transceiver for each antenna, the present embodiment includes a number of transceivers M for the number of antennas N, where M is greater than or less than N. In other words, there are either fewer transceivers or more transceivers than antennas. One or more of the transceivers may be designated as operating transceivers M**1** and one or more of the transceivers may be designated as redundant transceivers M**2**. For example, in the embodiment of the system **10** shown in FIG. **1**, M=2 and N=4. The first transceiver **24***a* may be an operating transceiver M**1** and the second transceiver **24***b* may be a redundant transceiver M**2**. In another embodiment with ten antennas **16** (N=10), the transceiver bank **22** may, for example, include 4 transceivers (M=4), three of which are operating transceivers (M**1**=3), and one of which is a redundant transceiver (M**2**=3). It will be appreciated that M**1**+M**2**=M.

[**0030**] Although FIG. **1** shows an embodiment with four antennas and two transceivers, it will be appreciated that other embodiments may have more or fewer antennas and/or more transceivers.

[**0031**] The reader **20** further includes a switching network **28** for selectively connecting one of the transceivers **24***a*, **24***b*, and **24***n*, with one of the antennas **16**. In some embodiments, the switching network **28** may only connect one transceiver **24** to one antenna **16** at any given time; however, in other embodiments, the switching network **28** may allow for connections between more than one antenna **16** and respective transceivers **16**. For example, with reference to FIG. **2**, the switching network **28** may contemporaneously connect the first antenna **16***a* to the first transceiver **24***a* and the fourth antenna **16**d to the second transceiver **24***b*. In this latter circumstance, the antennas **16** that are contemporaneously connected to a respective one of the transceivers **24** may be spatially displaced to ensure no overlap. In other words, the switching network **28** may not simultaneously connect transceivers **24** to two antennas **16** located in adjacent lanes of the roadway **14**, since RF interference may result.

[**0032**] The switching network **28** operates under the control of the controller **26**, which causes the switching network **28** to connect and disconnect specified antennas **16** to selected transceivers **24** so as to implement a scanning pattern. The scanning pattern may include a fixed pattern of equal length timeslots. In some embodiments, the scanning pattern may include an adaptive pattern that adjusts to traffic volume differences between the laneways, as described in U.S. provisional 60/718,743, filed Sep. 21, 2005 and owned in common herewith, the contents of which are hereby incorporated.

[**0033**] The reader **20** may further include failure detection circuitry **30** for providing the controller **26** with information from which it may determine if one of the transceivers **24***a*, **24***b*, or **24***n* has failed. Through the detection circuitry **30** the controller **26** may receive a portion or sample of the RF signal output by each of the transceivers **24**. Based upon the output signal from a selected transceiver **24**, the controller **26** may determine whether the transceiver **24** is functioning normally. If one of the transceivers **24** fails, then the controller **26** may remove it from operation by controlling the switching network **28** such that the failed transceiver **24** is not used. For example, if the first transceiver **24***a* fails, then the switching network **28** may use the second transceiver **24***b* in its place.

[**0034**] In one embodiment, the detection circuitry **30** may include a directional coupler **31***a*, **31***b*, **31***c* for obtaining a portion of each transceiver output. The directional couplers **31** may include a low loss tap for obtaining a small portion of the RF signal without significantly reducing the dBmV of the through signal. In one embodiment, the system **10** operates within the **915** MHz frequency band. In other embodiments, the system **10** may use other frequency bands, such as, for example, 5.9 GHz. By way of example only, to minimize impact on the power transmitted to the antenna **16**, the directional coupler **31** may be a 20 dB tap in which 99% of the power of the input signal passes through the directional coupler **31** and 1% of the power is split off for use in failure detection, as is described below. Selection of an appropriate directional coupler **31** for a specific application will be within the knowledge of a person ordinarily skilled in the art.

[**0035**] The detection circuitry **30** may also include threshold circuitry **32***a*, **32***b*, **32***c*, for determining whether the RF power level of the tapped signal drops below a threshold level. The threshold level may be predetermined or may be controlled dynamically by the controller **26**. Output signals from the threshold circuitry **32** corresponding to each transceiver **24** may be input to the controller **26**. On this basis, the controller **26** may assess whether the individual transceivers **24** are operating normally. The threshold circuitry **32** may include various discrete components, including filters, etc., for determining or detecting the power level of an RF signal and comparing it against a threshold level, as will be appreciated by those of ordinary skill in the art.

[**0036**] Reference is made to FIG. **3**, which diagrammatically shows an example embodiment of the failure detection circuitry **30**. The circuitry **30** includes the directional coupler **31** for obtaining a portion of the output signal from the transceiver **24** (FIG. **1**). The directional coupler **31** outputs the portion as a tapped signal **38**. The tapped signal **38** is input to the threshold circuitry **32**. In this embodiment, the threshold circuitry **32** includes a down-converter or mixer **40** and a peak detector **41**. The mixer **40** receives the tapped signal **38** and the carrier frequency, which in some embodiments is in the **915** MHz band, and outputs a baseband or IF signal. This signal is then input to the peak detector **41**, which outputs a DC signal **42** that has a voltage level that may be used as a proxy for measuring the power output level of the transceiver **24**.

[**0037**] The threshold circuitry **32** may also include a comparator **46**. The comparator **46** receives, as inputs, the DC signal **42** and a threshold signal **44**. The threshold signal **44** has a pre-set DC level that represents the minimum level that the DC signal **42** must exhibit. If the DC signal **42** falls below the threshold signal **44** level, it is indicative that the output power of the transceiver **24** has fallen below the minimum level permitted. The threshold signal **44** may be predetermined through a voltage divider within the threshold circuitry **32**. In another embodiment, the threshold signal **44** is generated by a digital circuit pre-programmed to output the threshold signal **44** and the predetermined level. In yet another embodiment, the threshold signal **44** is output by a signal generator circuit **52** operating under the control of the controller **26**. In such an embodiment, the controller **26** may adjust the level of the threshold signal **44** from time-to-time.

[0038] The comparator **46** outputs a result signal **50** based upon the comparison between the DC signal **42** and the threshold signal **44**. For example, the comparator **46** may output a LOW signal if the DC signal **42** remains above the threshold signal **44**, and may output a HIGH signal if the DC signal **42** falls below the threshold signal **44**. In some embodiments, the comparator **46** may be implemented using an op-amp or similar integrated circuit. The result signal **50** may be buffered through a buffer circuit **48** before being input to a failure detection input port **54** of the controller **26**.

[0039] Reference is now made to FIG. **4**, which shows an alternative embodiment of the failure detection circuitry **30**. In this embodiment, the failure detection circuitry **30** includes the mixer **40** and the peak detector **41** and includes an analog-to-digital converter **60** for receiving the DC signal **42** and converting it to a digital signal **62**. The analog-to-digital converter **60** quantizes and digitizes the DC signal **42**, outputting the digital signal **62** containing data regarding the signal level of the DC signal **42**. The digital signal **62** may then be input to the controller **26**, which may, through operations implemented in software or firmware, analyze the digital signal **62** to detect whether the output signal level of the transceiver **24** falls below a predetermined threshold.

[0040] Other methods and mechanisms for implementing the failure detection circuitry **30**, and the threshold detection circuitry **32** in particular, will be understood by those of ordinary skill in the art having regard to the present description.

[0041] Reference is now made to FIG. **5**, which shows, in flowchart form, a method **100** for adaptively switching transceiver usage in an electronic toll collection (ETC) system. The ETC system includes, at a given roadside plaza or toll location, N antennas and M transceivers, where N does not equal M.

[0042] The method **100** begins in step **102** upon initialization of the ETC system. In step **102**, certain parameters and default settings are established. For example, a subset of the M transceivers are designated as the active transceivers. The active transceivers are the transceivers used by the reader to conduct toll transactions with transponders in the roadway in accordance with a scanning pattern. In one embodiment, there is an active transceiver for each of the N antennas. However, in the general case, there are fewer active transceivers than there are antennas, thereby requiring that the reader control a switching network to connect an active transceiver to each antenna in its turn according to the scanning pattern. In one embodiment, there is one active transceiver that is used for all antennas.

[0043] The remaining transceiver(s) are designated as redundant transceivers.

[0044] In step **104**, the ETC system performs its ETC operations through excitation of a selected antenna with one of the active transceivers, in accordance with the scanning pattern. In step **106**, the output signal from the active transceiver is tapped and analyzed to determine whether the transceiver is operating correctly. If the power level is sufficient—i.e. above the threshold—then the method returns to step **102** and the ETC system continues its normal operation. If, in step **106**, the system determines that one of the active transceivers has an output power level that has fallen below the threshold level, then the method **100** proceeds to step **108**.

[0045] In step **108**, the active transceiver with the low output power is removed/excluded from the set of active transceivers. It may be designated as "failed" or "inoperative", so that it is not used again the ETC operation until repaired. The ETC system may output an indicator to alert an operator to the need for repair. For example, the ETC system may output a failure signal through a communications port. The ETC system may also or alternatively, provide a visual indicator, such illuminating an LED on the reader, intended to alert personnel to the need for repair. A failure signal may include data regarding the nature of the error detected and identifying the transceiver.

[0046] In step **110**, if a redundant transceiver is available, then the redundant transceiver may be added to the set of active transceivers in place of the failed transceiver.

[0047] It will be appreciated that step **110** may not always be carried out. For example, in some cases there may be no redundant transceivers available. Provided that the ETC system contains at least one active transceiver in addition to the failed transceiver, then the ETC system may continue to operate without adding a redundant transceiver. However, if the failed transceiver was the only active transceiver and there are no redundant transceivers available, then the ETC system may be unable to continue to operate until adjustments or repairs are made to one or more of the transceivers.

[0048] The present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. Certain adaptations and modifications of the invention will be obvious to those skilled in the art. Therefore, the above discussed embodiments are considered to be illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed is:

1. An electronic toll collection system for conducting toll transactions with vehicle-mounted transponders travelling in a multi-lane roadway, the electronic toll collection system comprising:

one or more antennas for engaging in RF communications with transponders, each antenna defining a capture zone in a portion of at least one lane of the multi-lane roadway;

two or more RF transceivers, each RF transceiver having an RF port;

a switching network connected to the antennas and to the RF ports of the transceivers, the switching network selectively connecting at least one of said transceivers to at least one of said antennas;

a controller for controlling the switching network and the transceivers; and failure detection circuitry connected to the RF ports of the transceivers for detecting whether any of the transceivers output an RF signal having a power level below a threshold level, the failure detection circuitry providing a result signal to the controller,

whereby the controller is configured to control the switching network to connect the antennas to the transceivers in accordance with a scanning pattern, and wherein the controller is configured to cause the switching network exclude one of the transceivers if the result signal from the failure detection circuitry indicates a failure in said one of the transceivers.

2. The system claimed in claim 1, wherein said failure detection circuitry comprises a directional coupler providing a tapped signal through a tap port and a threshold circuit for comparing the power level of said tapped signal with a threshold.

3. The system claimed in claim 2, wherein said threshold circuit comprises a down-converter and a peak detector for receiving said tapped signal and producing a DC signal, and a comparator for receiving the DC signal and a predefined threshold signal.

4. The system claimed in claim 1, wherein one or more of said transceivers comprise active transceivers and at least one of said transceivers comprises a redundant transceiver, and wherein said controller is configured to re-designate said redundant transceiver as one of said active transceivers if the result signal from the failure detection circuitry indicates a failure in said one of the transceivers, thereby replacing said one of the transceivers with said redundant transceiver.

5. The system claimed in claim 1, wherein the failure detection circuitry is at least partly implemented by said controller.

6. A method for adaptively switching transceiver usage in an electronic toll collection system used to conduct toll transactions with vehicle-mounted transponders travelling in a multi-lane roadway, the system including one or more antennas for engaging in RF communications with transponders, two or more RF transceivers wherein each RF transceiver has an RF port, and a switching network connected to the antennas and to the RF ports of the transceivers, the switching network selectively connecting at least one of the transceivers to at least one of the antennas under control of a controller, and wherein the system further includes failure detection circuitry connected to the RF ports for detecting whether any of the transceivers output an RF signal having a power level below a threshold level, the failure detection circuitry providing an output signal to the controller, the method comprising steps of:

designating a set of active transceivers, wherein the set of active transceivers includes at least one of said transceivers;

conducting RF communications through one of the antennas using said set of active transceivers;

determining that the RF signal from one of said active transceivers falls below a threshold power level; and

excluding said one of said active transceivers from the set of active transceivers.

7. The method claimed in claim 6, wherein the step of designating further includes designating one of said transceivers as a redundant transceiver, and wherein said method further includes a step of adding said redundant transceiver to said set of active transceivers in place of said one of said active transceivers in response to said step of determining.

8. The method claimed in claim 6, wherein said step of determining includes measuring a power level of the RF signal and comparing the power level with said threshold power level.

9. The method claimed in claim 8, wherein said step of determining includes tapping the RF signal to obtain a tapped signal, and comparing the power of the tapped signal with a preset threshold.

10. The method claimed in claim 9, wherein said step of comparing includes down-converting and peak detecting the tapped signal to create a DC voltage signal, and comparing the DC voltage signal with a threshold voltage signal.

11. The method claimed in claim 6, wherein said steps of conducting and determining include transmitting an RF trigger signal and measuring the power level of said RF trigger signal at the RF port.

12. An electronic toll collection system for conducting toll transactions with vehicle-mounted transponders travelling in a multi-lane roadway, the electronic toll collection system comprising:

one or more antennas for engaging in RF communications with transponders;

two or more RF transceivers, each RF transceiver having an RF port;

controller means for controlling the transceivers to implement a scanning pattern

switching means connected to the antennas and to the RF ports of the transceivers, the switching means selectively connecting at least one of said transceivers to at least one of said antennas under control of the controller means; and

failure detection means connected to the RF ports of the transceivers for detecting whether any of the transceivers output an RF signal having a power level below a threshold level, the failure detection means providing a result signal to the controller means,

wherein the controller means further includes means for causing the switching means to connect the antennas to the transceivers in accordance with a scanning pattern, and wherein the controller means includes means for causing the switching network exclude one of the transceivers if the result signal from the failure detection means indicates a failure in said one of the transceivers.

13. The system claimed in claim 12, wherein one or more of said transceivers comprise active transceivers and at least one of said transceivers comprises a redundant transceiver, and wherein said controller means further comprises means for re-designating said redundant transceiver as one of said active transceivers in response to said result signal.

14. The system claimed in claim 12, wherein said failure detection means includes envelope detection means for performing envelope detection upon said RF signal and outputting a voltage signal.

15. The system claimed in claim 14, wherein said failure detection means further comprises comparing means for comparing said voltage signal with a threshold voltage signal to determine whether the power level of said RF signal is below said threshold level.

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