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(54) **Title**: ANTENNA SYSTEM AND METHOD FOR OPTIMIZING AN RF SIGNAL

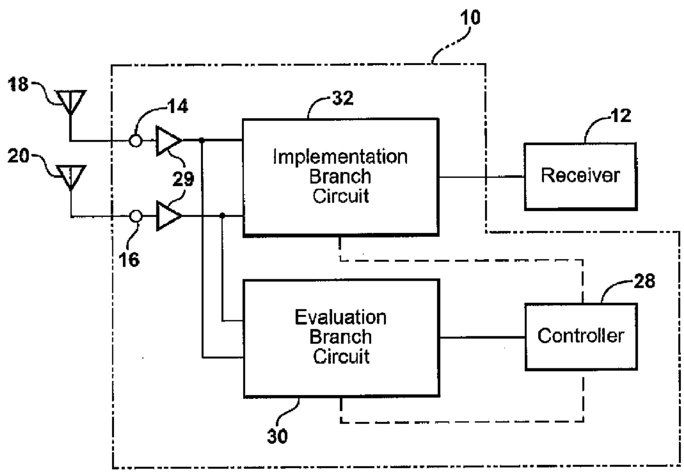

FIG. 1

(57) **Abstract**: An antenna system and method utilize an evaluation branch circuit and an implementation branch circuit. These circuits are each connected to both a first antenna input and a second antenna input. An output of the evaluation branch circuit is in communication with a controller while an output of the implementation branch circuit is in communication with a receiver. Each branch circuit includes at least one signal conditioner to change an electrical characteristic of RF signals received from antennas via the antenna inputs. The evaluation branch circuit, controlled by the controller, changes the electrical characteristics of the RF signals in a variety of different ways to discover an optimized evaluation RF signal. Once the optimized evaluation RF signal is determined, the implementation branch circuit is controlled, by the controller, to produce an optimized implementation RF signal in accordance with that discovered by the evaluation branch circuit.

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ANTENNA SYSTEM AND METHOD FOR OPTIMIZING AN RF SIGNAL

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of United States provisional patent application Nos. 61/268,662, 61/268,663, 61/268,665, 61/268,673, 61/268,674, and 61/268,689, each filed on June 15, 2009 and each of which is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The subject invention relates to an antenna system and method for optimizing RF signal reception.

2. Description of the Related Art

[0003] A receiver performs most effectively when the RF signal it receives is optimized due to a high signal strength and low signal-to-noise ratio. When both the transmitting and receiving antennas are fixed, achieving an optimized RF signal may be accomplished by changing the directionality of one or both of the antennas. However, when either the transmitting or receiving antenna is in motion, such as a receiving antenna disposed on a vehicle or a transmitting antenna on a non-geosynchronous satellite, obtaining the optimized RF signal is more challenging.

[0004] One technique for obtaining an optimized RF signal involves combining by shifting the phase and/or adjusting the amplitude of multiple RF signals and supplying the resulting RF signal to the receiver, as this will change the electrical characteristics of the RF signal. However, the amount of phase shift and/or amplitude adjustment is variable based on any number of factors, including the distance between the transmitting and receiving antennas, the inclination angle of the antennas with respect to one another, the size of the antenna, and the type of antenna. To further complicate the challenge, multiple receiving antennas may also be utilized. Furthermore, switching noise and low signal strength at the receiver may result during the aforementioned process of obtaining the optimized RF signal.

[0005] The subject invention is directed to addressing the problems and challenges associated with the related art.

BRIEF SUMMARY AND ADVANTAGES

[0006] The subject invention defines an antenna system including a first antenna input for receiving a first RF signal from a first antenna and a second antenna input for receiving a second RF signal from a second antenna. The system includes an evaluation branch circuit having at least one evaluation signal conditioner electrically connected to one of the antenna inputs for changing an electrical characteristic of at least one of the RF signals. The evaluation branch circuit also has an evaluation combiner electrically connected to one of the at least one evaluation signal conditioner and at least one of another of the at least one evaluation signal conditioner, the first antenna input, and the second antenna input for combining at least two of the RF signals to produce an evaluation RF signal. The system further includes an implementation branch circuit separate from the evaluation branch circuit. The implementation branch circuit has at least one implementation signal conditioner electrically connected to one of the antenna inputs for changing an electrical characteristic of at least one of the RF signals. An implementation combiner is electrically connected to one of the at least one implementation signal conditioner and at least one of another of the at least one implementation signal conditioner, the first antenna input, and the second antenna input for combining at least two of the RF signals to produce an implementation RF signal. The system also includes a controller electrically connected to the evaluation combiner for receiving the evaluation RF signal from the evaluation combiner. The controller is in communicative control of the at least one evaluation signal conditioner to produce a plurality of evaluation RF signals, with each evaluation RF signal having different electrical characteristics. The controller analyzes the plurality of evaluation RF signals to determine an optimized evaluation RF signal from the plurality of evaluation RF signals. The controller is also in communicative control of the at least one implementation signal conditioner for changing the electrical characteristic of at least one of the RF signals based on the optimized evaluation RF signal to produce an optimized implementation RF signal.

[0007] The subject invention also defines a method of providing an optimized RF signal to a receiver where a first RF signal is received from a first antenna and a second RF signal is received from a second antenna. The method includes the step of changing an electrical characteristic of at least one of the RF signals in an evaluation branch circuit having multiple ways to produce a plurality of evaluation RF signals, where each evaluation RF signal has different electrical characteristics. The plurality of evaluation RF signals is received at a controller. The method also includes the step of analyzing the plurality of evaluation RF signals with the controller to determine an optimized evaluation RF signal. The method further includes the step of changing an electrical characteristic of at least one of the RF signals in an implementation branch circuit in accordance with the optimized evaluation RF signal determined by the controller.

[0008] By utilizing separate evaluation and implementation branch circuits, the system and method optimize the RF signal to the receiver without subjecting the receiver to multiple non-optimized RF signals. Furthermore, switching noise, which occurs when the electrical characteristics of the RF signals are altered, are reduced as the receiver is not subjected to constantly changing RF signals. As such, the receiver typically receives the optimized RF signal in terms of signal strength and signal-to-noise ratio .

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Other advantages of the present invention will be readily appreciated, as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0010] Figure 1 is a block schematic diagram of an antenna system having an implementation branch circuit and an evaluation branch circuit;

[0011] Figure 2 is a perspective view of a vehicle showing a first antenna group and a second antenna group disposed on a window;

[0012] Figure 3 is a block schematic diagram of a first embodiment of the system with one phase shift circuit and one attenuator in each branch circuit;

[0013] Figure 4 is a block schematic diagram of a second embodiment of the system with two phase shift circuits and two attenuators in each branch circuit; and

[0014] Figure 5 is a block schematic diagram of a third embodiment of the system with an additional implementation branch circuit.

DETAILED DESCRIPTION OF THE INVENTION

[0015] Referring to the Figures, an antenna system **10** and method of optimizing a radio frequency (RF) signal for delivery to a receiver **12** are described herein.

[0016] Referring to Figure 1, the antenna system **10** includes a first antenna input **14** for receiving a first RF signal and a second antenna input **16** for receiving a second RF signal. The RF signals, as known to those skilled in the art, are oscillating waveforms having a frequency between 3 Hz and 300 GHz. The RF signals in the illustrated embodiment are preferably transmitted through the air and carry information such as computerized data, audio signals, etc. as is also well known to those skilled in the art. Furthermore, the RF signals may be transmitted from terrestrial sources, from a satellite, or by other techniques known to those skilled in the art. Moreover, although the antenna system **10** utilizes inputs **14**, **16** for receiving RF signals, the system **10** may be alternatively utilized to transmit RF signals via multiple outputs (not shown). However, for ease in description purposes, the system **10** will be described hereafter as receiving RF signals. Furthermore, the antenna system **10** may also include additional antenna inputs to receive additional RF signals.

[0017] In the illustrated embodiments, the first antenna input **14** is electrically connected to a first antenna group **18** which provides the first RF signal and the second antenna input **16** is electrically connected to a second antenna group **20** which provides the second RF signal. As shown in Figure 2, each antenna group **18**, **20** includes a plurality of antenna elements **22** for receiving the RF signals. The antenna groups **18**, **20** are also commonly referred to as antenna arrays by those skilled in the art. However, in alternative embodiments (not shown) the antenna inputs **14**, **16** may be connected to single antenna elements **22**.

[0018] In the embodiment shown in Figure 2, the antenna groups **18**, **20** are disposed on one or more windows **24** of a vehicle **26**. Accordingly, the antenna elements **22** of the antenna groups **18**, **20** are also disposed on the window(s) **24**. The antenna elements **22** are formed of a conductive material, such as, but not limited to, copper or silver. The antenna elements **22** may be shaped as patches, strips, wires, or any other suitable form as known to those skilled in the art.

[0019] Referring again to Figure 1, the antenna system **10** includes a controller **28** for controlling operation of the system **10**. The controller **28** is preferably implemented as a microprocessor, a microcontroller, a field programmable gate array (FPGA), a combination of discrete logic devices, or other suitable circuitry able to store and perform computations of data. Such microprocessors and microcontrollers are widely available and well known to those skilled in the art. Furthermore, a plurality of devices may be implemented in communication with one another to implement the controller **28**. The functions and capability of the controller **28** will be described in greater detail below.

[0020] One or more amplifiers **29** may be utilized in conjunction with the system **10**. Each amplifier **29** is electrically connected to one of the antenna inputs **14**, **16**. In first and second embodiments, as shown in Figures 3 and 4 respectively, the amplifiers **29** are implemented as a first amplifier **29A** electrically connected to the first antenna input **14** and a second amplifier **29B** electrically connected to the second antenna input **16**. The amplifiers **29** each amplify the RF signal received from corresponding antenna group **18**, **20**. Said another way, each amplifier **29** increases the signal strength of each RF signal. The amplifiers **29** are preferably low-noise amplifiers (LNAs), however, other types may be utilized as well known to those skilled in the art. Furthermore, multiple amplifiers **29** may be electrically connected in series (not shown) and electrically connected to one of the antenna inputs **14**, **16**.

[0021] With reference to Figure 1, the antenna system **10** includes an evaluation branch circuit **30** and an implementation branch circuit **32**. The receiver **12** is electrically connected to the implementation branch circuit **30** such that the implementation branch circuit **32** provides the RF signal that is supplied to the receiver **12**. The evaluation branch circuit **30** is utilized to determine an optimized RF signal as described below. Each branch circuit **30**, **32** is electrically connected to both of the antenna inputs **14**, **16**. Specifically, in the illustrated embodiments, each branch circuit **30**, **32** is electrically connected to an output (not numbered) of each of the amplifiers **29**. As such, both the implementation branch circuit **32** and the evaluation branch circuit **30** utilize both the first and second RF signals received from the first and second antenna groups **18**, **20**. However, the implementation branch circuit **32** is separate from the evaluation branch circuit **30**. That is, although the branch circuits **30**, **32** each contain the same or similar components (as described below), the implementation branch circuit **32** is electrically connected to the receiver **12**, while the evaluation branch circuit **30** is not connected to the receiver **12**.

[0022] Referring now to Figures 3 and 4, each branch circuit **30**, **32** includes at least one signal conditioner **33** electrically connected to one of said antenna inputs **14**, **16** for changing an electrical characteristic of at least one of the RF signals. In the illustrated embodiments, the at least one signal conditioner **33** is implemented with a phase shifter **34** and an attenuator **36** as described in greater detail below. However, those skilled in the art realize other configurations, quantities, and types of suitable signal conditioners **33** other than those described herein.

[0023] Still referring to Figures 3 and 4, the circuits **30**, **32** each include at least one phase shifter **34**. The at least one phase shifter **34** is in communication with one of the first antenna input **14** and the second antenna input **16**. That is, one phase shifter **34** may be in communication with either the first antenna input **14** or the second antenna input **16**. Further, multiple phase shifters **34** may be utilized such that one phase shifter **34** is in communication with to the first antenna input **14** and another phase shifter **34** is in communication with to the second antenna input **16**.

[0024] The at least one phase shifter **34** receives the RF signal from each of the connected antenna inputs **14**, **16**. The phase shifter **34** shifts the phase of the received RF signal to generate a phase-shifted RF signal. Said another way, the phase shifter **34** provides a time delay to the received RF signal to generate the phase-shifted RF signal. The at least one phase shifter **34** is also in communication with the controller **28**. Specifically, the controller **28** may control the amount of phase shift, or time delay, that is applied to the RF signal received from the antenna inputs **14**, **16**.

[0025] In the first embodiment of the system **10**, as shown in Figure 3, the evaluation branch circuit **30** includes a first evaluation phase shifter **34A** electrically connected to an output (not numbered) of the first amplifier **29A**. Likewise, the implementation branch circuit **32** includes a first implementation phase shifter **34B** also electrically connected to the output of the first amplifier **29A**.

[0026] In a second embodiment, as shown in Figure 4, the evaluation branch circuit **30** includes the first evaluation phase shifter **34A** and the first implementation phase shifter **34B** electrically connected to the first amplifier **29A**.

Additionally, a second evaluation phase shifter **34C** and a second implementation phase shifter **34D** are electrically connected to an output (not numbered) of the second amplifier **29B**.

[0027] The circuits **30**, **32** may also include the attenuator **36** as one of the at least one signal conditioner **33**. Each attenuator **36** attenuates one of the RF signals. That is, the attenuators **36** each reduce the signal strength of the RF signal. Each attenuator **36** is in communication with the controller **28** such that the controller **28** may control the amount or level of attenuation in each attenuator **36**. Said another way, the controller **28** manages how much signal strength is reduced by each attenuator **36**. By attenuating one or more of the RF signals, the controller **28** optimizes the combined RF signal delivered to the receiver **12**, as described in more detail below.

[0028] Preferably, the at least one attenuator **36** is electrically connected to an output (not numbered) of the at least one phase shifter **34**. However, other connection locations for the at least one attenuator **36** will be realized by those skilled in the art.

[0029] In the first embodiment, as shown in Figure 3, the at least one attenuator **36** is implemented as a first attenuator **36A** electrically connected to the first phase shifter **34A** as part of the evaluation branch circuit **30** and a second attenuator **36B** electrically connected to the second phase shifter **34B** as part of the implementation branch circuit **32**. In the second embodiment, in addition to the first and second attenuators **36A**, **36B**, the evaluation branch circuit **30** includes a third attenuator **36C** electrically connected to the third phase shifter **34C** and the implementation branch circuit **32** includes a fourth attenuator **36D** electrically connected to the fourth phase shifter **34D**.

[0030] The system **10** also includes at least two combiners **38**. Specifically, the system **10** includes an evaluation combiner **38A**, as part of the evaluation branch circuit **30**, and an implementation combiner **38B**, as part of the implementation branch circuit **32**. Each combiner **38A**, **38B** has at least two inputs (not numbered) for receiving RF signals and an output. A first input of each combiner **38A**, **38B** is electrically connected to one of the at least one phase shifter **34** or attenuator **36**. A second input of the combiner **38** is electrically connected to at least one of another of the at least one phase shifter **34**, another of the attenuator **36**, the first antenna input **14**, or the second antenna input **16**. That is, the second input of the combiner **38** is electrically connected to one of the phase shifters **34**, the first antenna input **14**, or the second antenna input **16**. The evaluation combiner **38A** combines the RF signals received from the inputs and delivers an evaluation RF signal to the output. Likewise, the implementation combiner **38B** combines the RF signals received from the inputs and delivers an implementation RF signal to the output. The output of the implementation combiner **38B** is connected solely to the receiver **12**. Said another way, the output of the implementation combiner **38B** is electrically isolated from the controller **28**.

[0031] In the first embodiment, the first input of the evaluation combiner **38A** is electrically connected to the first attenuator **36A** and the second input is electrically connected to the second amplifier **29B**. The first input of the implementation combiner **38B** is electrically connected to the second attenuator **36B** and the second input is also electrically connected to the second amplifier **29B**.

[0032] In the second embodiment, the inputs of evaluation combiner **38A** are electrically connected to the first attenuator **36A** and the third attenuator **36C**.

The inputs of the implementation combiner **38B** are electrically connected to the second attenuator **36B** and the fourth attenuator **36D**.

[0033] The output of the evaluation combiner **38A** is in communication with the controller **28**. The controller **28** then evaluates the evaluation RF signal. More specifically, the controller **28** changes the electrical characteristics of the RF signals in the evaluation branch circuit **30**, at a plurality of different levels. This is done to find an optimized evaluation RF signal. In the illustrated embodiments, changing the electrical characteristics of the RF signals is accomplished by changing the amount of phase shift generated by the at least one phase shifter **34** and/or the amount of attenuation by the attenuators **36**. For example, the RF signal may be phase shifted by 2.5°, 5°, 7.5°, 10°, and so on, to generate a plurality of evaluation RF signals. As another example, the RF signal may be attenuated by 0.5 dB, 1 dB, etc., to generate the plurality of evaluation RF signals. Of course, the RF signal may be phase shifted and attenuated at a plurality of different levels to generate a plurality of unique evaluation RF signals.

[0034] The controller **28** may implement a null steering technique to optimize the evaluation RF signal, and thus also optimize the implementation RF signal delivered to the receiver **12**. As stated above, controller **28** is in communication with each phase shifter **34** and attenuator **36** for controlling operation of the phase shifters **34** and attenuators **36**. Specifically, the controller **28** may increase or decrease the amount of attenuation provided by the attenuators **36** on each RF signal. That is, the controller **28** may increase or decrease the signal strength of each RF signal. The controller **28** may also change the phase shift on the RF signals. The system **10** may also include additional amplifiers (not shown) in-line with the phase shifters **34**. These amplifiers may be utilized in addition to, or as an alternative, to the attenuators **36**. These amplifiers are in communication with the controller **28** for increasing or decreasing the signal strength of each RF signal.

[0035] The controller **28** controls the signal strength and/or phase shift of the signals in an attempt to reduce interference from undesired RF signals. For instance, if the receiver **12** is tuned to a desired RF signal on a certain frequency, interference from other nearby signals at different frequencies can often cause interference to the desired RF signal. Furthermore, distant signals at the certain frequency can also cause interference to the desire RF signal. As such, the controller **28**, by adjusting the signal strength and/or phase shift of the RF signals received by the antennas **22**, steers a null in the radiation pattern to mitigate the interference. This is accomplished by analyzing the signal-to-noise ratio (SNR) of each signal received by the controller **28**. Phase adjustments may be made to the phase shifters **36** to determine the best SNR at the frequency of the desired RF signal.

[0036] Once the optimized evaluation RF signal is found, the controller **28** changes the electrical characteristics of the RF signal in the implementation branch circuit **32** to match those of the optimized evaluation RF signal found by the evaluation branch circuit **30**. As such, the implementation RF signal delivered to the receiver **12** is optimized. By using this technique, i.e., using separate branch circuits **30**, **32**, the receiver **12** receives an optimized RF signal from the implementation branch circuit **32** without being subjected to a plurality of non-optimized RF signals of the evaluation branch circuit **30**. Furthermore, switching noise to the receiver **12** is reduced, as the RF signal delivered to the receiver **12** is not switching through the plurality of different electrical characteristics in order to find the optimized RF signal. The evaluation branch circuit **30** may routinely or continuously cycle through the plurality of different electrical characteristics in order to find the optimized RF signal, while the implementation branch circuit **32** utilizes the electrical characteristics associated with the last known optimized RF signal.

[0037] In the illustrated embodiments, the system **10** includes a signal strength identifier **40**. The signal strength identifier **40** is electrically connected to the evaluation combiner **38A** to determine the signal strength of the evaluation RF signal generated by the evaluation combiner **38A**. In the illustrated embodiment, the signal strength identifier **40** outputs an analog signal that corresponds with the signal strength of the evaluation RF signal. An analog-to-digital converter (ADC) **42** is electrically connected to the controller **28**, such that the controller **28** receives the signal strength as a digital value. Those skilled in the art realize that the signal strength identifier **40** and/or the ADC **42** may be integrated with the controller **28**.

[0038] The controller **28** preferably includes a parameter bank **44** for storing a plurality of possible electrical characteristics used in controlling the signal conditioners **33**. Specifically, the parameter bank **44** stores a plurality of possible phase and amplitude settings used in controlling the phase shifters **34** and the attenuators **36**. The possible phase and amplitude settings in the parameter bank **44** may be reduced into a plurality of preferred phase and amplitude settings based on a custom parameter set, such as the number of antenna elements **22** used, location of the antenna elements **22** on the vehicle, and type of vehicle used. A custom parameter bank **46** stores this custom parameter set. The possible phase and amplitude settings may also be narrowed by real-time information from a global positioning system (GPS) receiver **48**, which is in communication with the controller **28**. The preferred phase and amplitude settings are stored in a weighted parameter bank **50**. The banks **44**, **46**, **50** are typically memory locations in a memory (not shown) of the controller

28. These banks **44**, **46**, **50** may also be referred to as databases by those skilled in the art.

[0039] Generally, the controller **28** cycles through and implements all of the preferred phase and amplitude settings stored in the weighted parameter bank **50** within the evaluation branch circuit **30**. The signal strength identifier **40** measures the signal strength of the evaluation RF signal corresponding to the preferred phase and amplitude setting implemented. The controller **28** stores and compares the signal strength corresponding to the preferred phase and amplitude settings implemented in the evaluation branch circuit **30** and determines the preferred phase and amplitude setting that results in the strongest signal strength. The controller **28** then implements the preferred phase and amplitude setting determined to result in the strongest signal strength within the implementation branch circuit **32** for ensuring the receiver **12** is provided with the signal with the strongest possible signal strength.

[0040] A third embodiment of the system **10**, as shown in Figure 5, builds on the second embodiment, by implementing an additional implementation branch **52** for supplying a combined RF signal to an additional receiver **54**. As such, the receiver **12** accommodates a first radio-based service while the additional receiver **54** accommodates a second radio-based service. For instance, the first radio-based service may be terrestrial radio, while the second radio-based service may be the global positioning system. Other suitable radio-based services include, but are not limited to, satellite radio (e.g., SDARS) or cellular telephone service.

[0041] The third embodiment of the system also preferably includes a third antenna input **56** and a fourth antenna input **58**. The third antenna input **56** is electrically connected to a third antenna group **60** which provides a third RF signal and the fourth antenna input **58** is electrically connected to a fourth antenna group **62**

which provides a fourth RF signal. A third amplifier **29C** is electrically connected to the third antenna input **56** and a fourth amplifier **29D** electrically connected to the fourth antenna input **58**. The additional implementation branch **52** is electrically connected to the third and fourth inputs **56**, **58**.

[0042] The additional implementation branch of the third embodiment is electrically connected to the third and fourth amplifiers **29C**, **29D**, and thus in communication with the third and fourth antenna groups **56**, **58**. Specifically, the additional implementation branch **52** includes a fifth phase shifter **34E**, a sixth phase shifter **34F**, a fifth attenuator **36E**, a sixth attenuator **36F**, and a third combiner **38C**. The fifth phase shifter **34E** is electrically connected to the third amplifier **29C** for receiving and phase-shifting the third RF signal. The sixth phase shifter **34F** is electrically connected to the fourth amplifier **29D** for receiving and phase-shifting the fourth RF signal. The fifth attenuator **36E** is electrically connected to the fifth phase shifter **34E** for receiving and attenuating the third RF signal. The sixth attenuator **36F** is electrically connected to the sixth phase shifter **34F** for receiving and attenuating the fourth RF signal. One input of the third combiner **38C** is electrically connected to the fifth phase shifter **34E** or the fifth attenuator **36E** for receiving the third RF signal while the other input of the third combiner **38C** is electrically connected to the sixth phase shifter **34F** or the sixth attenuator **36F** for receiving the fourth RF signal. The additional receiver **54** is electrically connected to an output of the third combiner **38C**.

[0043] In the third embodiment, the at least one signal conditioner **33** of the evaluation branch circuit **30** is electrically connectable to either the first and second RF signals or the third and fourth RF signals. Specifically, the evaluation branch circuit **30** includes a first switch **64** and a second switch **66**. The first switch **64** is electrically connected to both the first amplifier **29A** and the third amplifier **29C**

and, accordingly, outputs either the first RF signal or the third RF signal. The second switch **66** is electrically connected to both the second amplifier **29B** and the fourth amplifier **29D** and, accordingly, outputs either the second RF signal or the fourth RF signal. Both switches **64**, **66** are preferably controlled in unison such that the at least one signal conditioner **33** utilizes either the first and second RF signals or the third and fourth RF signals.

[0044] In operation, the evaluation branch circuit **30** evaluates the first and second RF signals associated with the implementation branch circuit **32** at a plurality of conditions and then switches to evaluate the third and fourth RF signals associated with the additional implementation branch circuit **52** at a plurality of conditions. As such, the evaluation branch circuit **30** of the third embodiment may be utilized to evaluate RF signals for a plurality of implementation branch circuits **32**, **52** without the need for additional evaluation branch circuits.

[0045] The present invention has been described herein in an illustrative manner, and it is to be understood that the terminology which has been used is intended to be in the nature of words of description rather than of limitation. Obviously, many modifications and variations of the invention are possible in light of the above teachings. The invention may be practiced otherwise than as specifically described within the scope of the appended claims.

CLAIMS

What is claimed is:

1. An antenna system comprising:

a first antenna input for receiving a first RF signal from a first antenna;

a second antenna input for receiving a second RF signal from a second antenna;

an evaluation branch circuit including

at least one evaluation signal conditioner electrically connected to one of said antenna inputs for changing an electrical characteristic of at least one of the RF signals, and

an evaluation combiner electrically connected to one of said at least one evaluation signal conditioner and at least one of another of said at least one evaluation signal conditioner, said first antenna input, and said second antenna input for combining at least two of the RF signals to produce an evaluation RF signal,

an implementation branch circuit separate from said evaluation branch circuit, said implementation branch circuit including

at least one implementation signal conditioner electrically connected to one of said antenna inputs for changing an electrical characteristic of at least one of the RF signals, and

an implementation combiner electrically connected to one of said at least one implementation signal conditioner and at least one of another of said at least one implementation signal conditioner, said first antenna input, and said second antenna input for combining at least two of the RF signals to produce an implementation RF signal; and a controller electrically connected to said evaluation combiner for receiving the evaluation RF signal from said evaluation combiner;

said controller in control of said at least one evaluation signal conditioner to produce a plurality of evaluation RF signals, each evaluation RF signal having different electrical characteristics;

said controller analyzing the plurality of evaluation RF signals to determine an optimized evaluation RF signal from the plurality of evaluation RF signals; and

said controller in communicative control of said at least one implementation signal conditioner to change the electrical characteristic of at least one of the RF signals based on the optimized evaluation RF signal to produce an optimized implementation RF signal.

2. An antenna system as set forth in claim 1 wherein said at least one evaluation signal conditioner is further defined as an evaluation phase shifter for shifting a phase of the evaluation RF signal and said at least one implementation signal conditioner is further defined as an implementation phase shifter for shifting a phase of the implementation RF signal.

3. An antenna system as set forth in claim 2 wherein said controller directs said at least one evaluation phase shifter through a plurality of phase shifts and evaluates the evaluation RF signal from said evaluation combiner at each of the plurality of phase shifts to determine the optimized evaluation RF signal.

4. An antenna system as set forth in claim 2 wherein said at least one evaluation phase shifter is further defined as a first evaluation phase shifter

electrically connected to said first antenna input and a second evaluation phase shifter electrically connected to said second antenna input.

5. An antenna system as set forth in claim 4 wherein said evaluation combiner is electrically connected to said first evaluation phase shifter and said second evaluation phase shifter.

6. An antenna system as set forth in claim 2 wherein said at least one implementation phase shifter is further defined as a first implementation phase shifter electrically connected to said first antenna input and a second implementation phase shifter electrically connected to said second antenna input.

7. An antenna system as set forth in claim 6 wherein said implementation combiner is electrically connected to said first implementation phase shifter and said second implementation phase shifter.

8. An antenna system as set forth in claim 1 further comprising:

a first amplifier electrically connected between said first antenna input and both said evaluation branch circuit and said implementation branch circuit; and

a second amplifier electrically connected between said second antenna input and both said evaluation branch circuit and said implementation branch circuit.

9. An antenna system as set forth in claim 1 wherein:

said at least one evaluation signal conditioner is further defined as at least one evaluation attenuator; and said at least one implementation signal conditioner is further defined as at least one implementation attenuator.

10. An antenna system as set forth in claim 9 wherein said controller is in control of said at least one evaluation attenuator and said at least one implementation attenuator for evaluating the evaluation RF signal from said evaluation combiner to determine the optimized evaluation RF signal and adjusting the attenuation provided by said at least one implementation attenuator based on the optimized evaluation RF signal to produce the optimized implementation RF signal.

11. An antenna system as set forth in claim 1 wherein an output of said implementation combiner is electrically connected to a receiver.

12. An antenna system as set forth in claim 1 wherein said controller includes a database for storing a plurality of possible electrical characteristics used in controlling said signal conditioners.

13. A method of providing an optimized RF signal to a receiver wherein a first RF signal is received from a first antenna and a second RF signal is received from a second antenna, said method comprising the steps of:

changing an electrical characteristic of at least one of the RF signals in an evaluation branch circuit to produce a plurality of evaluation RF signals, wherein each evaluation RF signal has different electrical characteristics;

receiving the plurality of evaluation RF signals at a controller;

analyzing the plurality of evaluation RF signals with the controller to determine an optimized evaluation RF signal;

changing an electrical characteristic of at least one of the RF signals in an implementation branch circuit in accordance with the optimized evaluation RF signal determined by the controller.

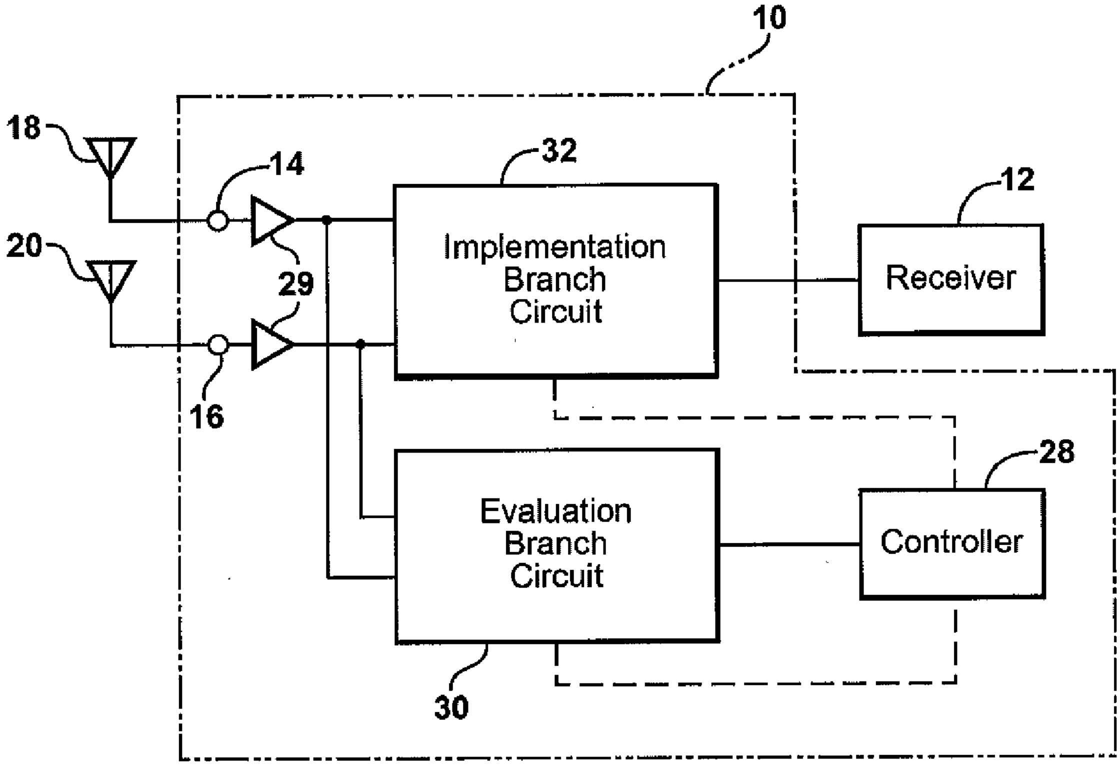
14. A method as set forth in claim 13 wherein said step of changing an electrical characteristic of at least one of the RF signals in an evaluation branch circuit is further defined as shifting the phase of at least one of the RF signals in the evaluation branch circuit at a plurality of different phases.

15. A method as set forth in claim 14 wherein said step of changing an electrical characteristic of at least one of the RF signals in an implementation branch circuit is further defined as shifting the phase of at least one of the RF signals in the implementation branch circuit to match the phase shift of the optimized evaluation RF signal to produce an optimized implementation RF signal.

16. A method as set forth in claim 13 further comprising the steps of amplifying the at least one RF signal in the evaluation branch circuit and amplifying the at least one RF signal in the implementation branch circuit.

17. A method as set forth in claim 16 wherein said step of changing an electrical characteristic of at least one of the RF signals in an evaluation branch circuit is further defined as attenuating at least one of the RF signals in the evaluation branch circuit.

18. A method as set forth in claim 17 wherein said step of changing an electrical characteristic of at least one of the RF signals in an implementation branch circuit is further defined as attenuating at least one of the RF signals in accordance with the attenuation determined by the controller.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Receiver
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29
16
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Evaluation
Branch
Circuit
Controller
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FIG. 1

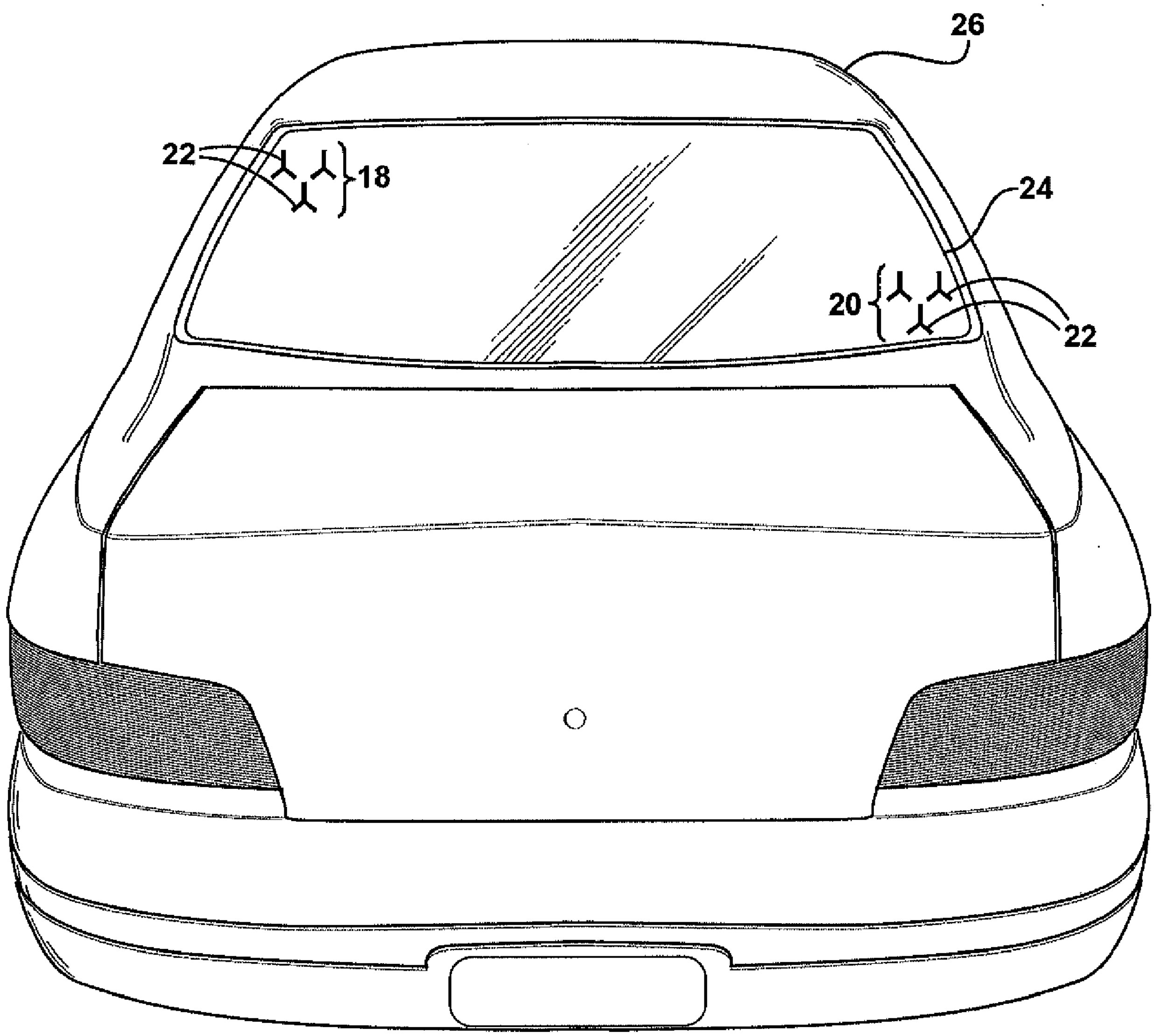

FIG. 2

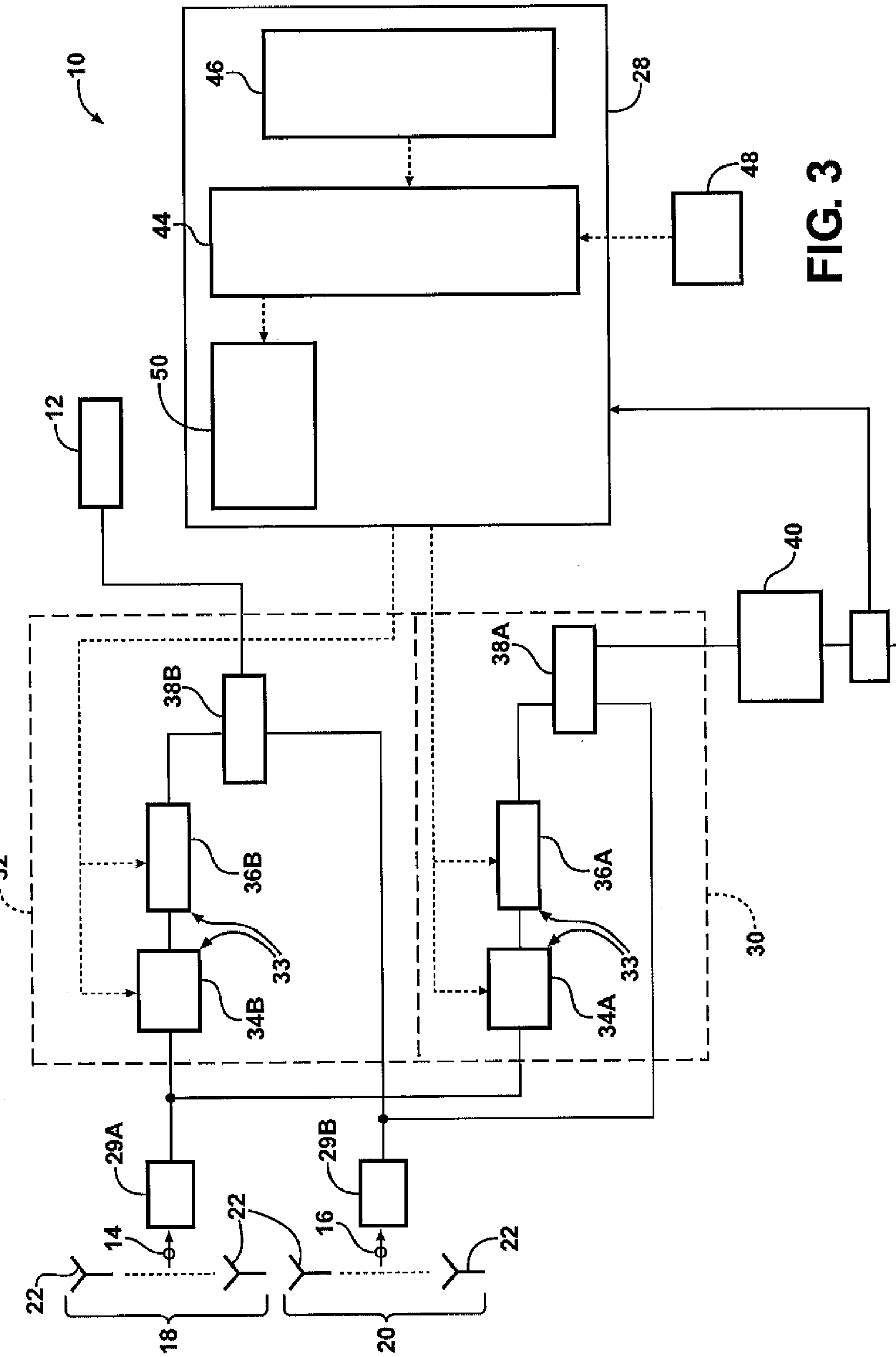
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FIG. 3

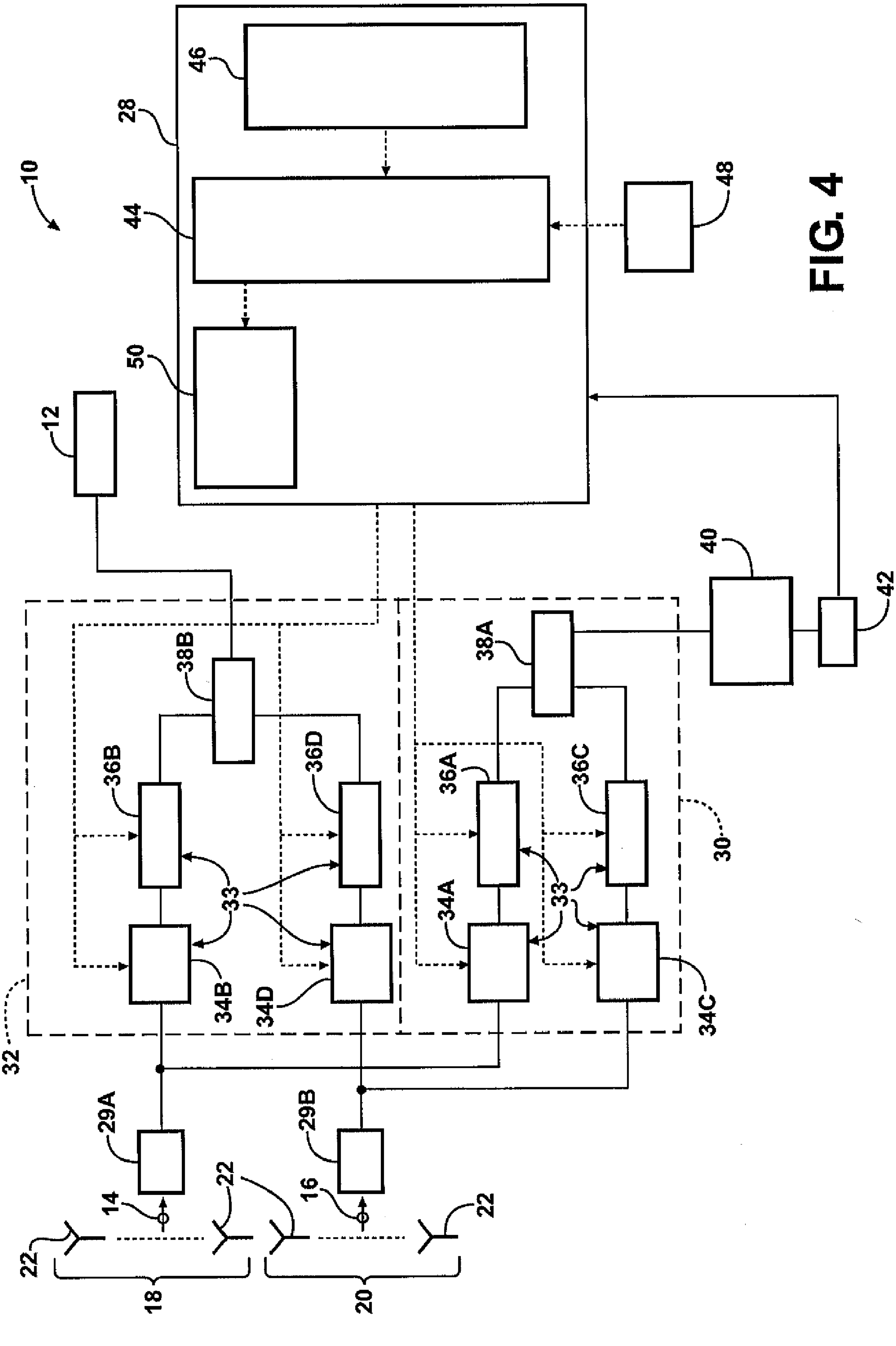
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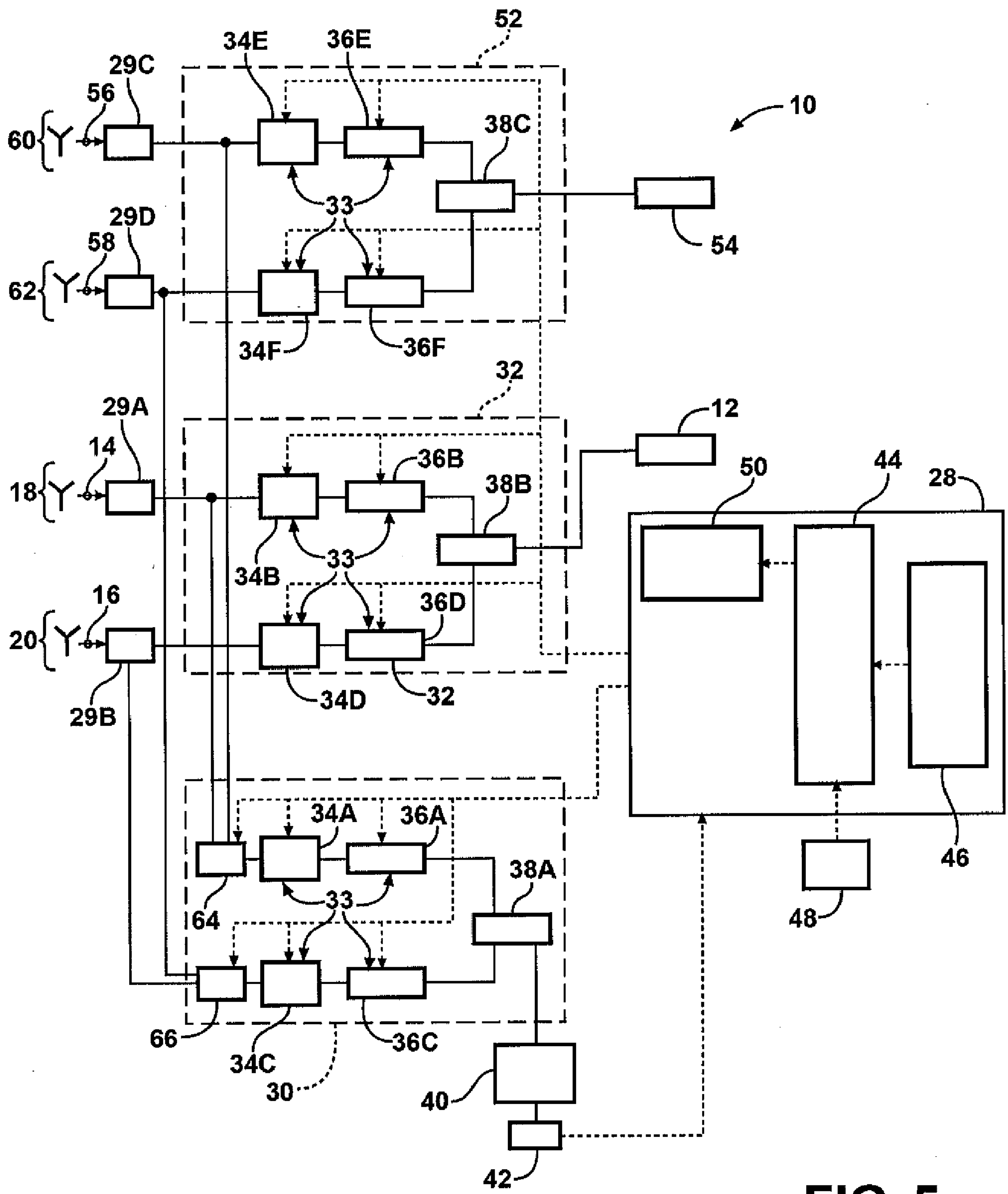
FIG. 4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29B
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38A
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34C
36C
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42

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2010/038669

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04B7/08 H01Q3/26
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B H01Q

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 7 016 399 B1 (VADGAMA SUNIL KESHAVJI [GB] ET AL) 21 March 2006 (2006-03-21) * abstract column 4, line 66 - column 8, line 28 figure 2 -----	1-18
A	EP 1 091 447 A1 (SIEMENS AG [DE]) 11 April 2001 (2001-04-11) * abstract paragraphs [0022] - [0026] figures 1-3 -----	1-18

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 October 2010	26/10/2010

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Helms, Jochen

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CHUN-NING ZHANG ET AL: "A low-complexity antenna diversity receiver suitable for TDMA handset implementation" VEHICULAR TECHNOLOGY CONFERENCE, 1997, IEEE 47TH PHOENIX, AZ, USA 4-7 MAY 1997, NEW YORK, NY, USA,IEEE, US LNKD-DOI:10.1109/VETEC.1997.605859, vol. 3, 4 May 1997 (1997-05-04), pages 1753-1757, XP010229068 ISBN: 978-0-7803-3659-9 the whole document -----	1-18
A	US 6 087 986 A (SHOKI HIROKI [JP] ET AL) 11 July 2000 (2000-07-11) * abstract column 9, line 19 - column 11, line 6 figures 12, 14 -----	1-18
A	US 2008/238773 A1 (YOSHIZOE KAZUKI [JP] ET AL) 2 October 2008 (2008-10-02) * abstract paragraphs [0009] - [0026] figure 9 -----	1-18

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2010/038669

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			WO	0033481	A1	08-06-2000
			JP	4252732	B2	08-04-2009
			JP	2002531993	T	24-09-2002
EP 1091447	A1	11-04-2001	NONE			
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