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(54) **ENHANCED TRANSMITTER USING FREQUENCY CONTROL FOR WIRELESS POWER TRANSMISSION**

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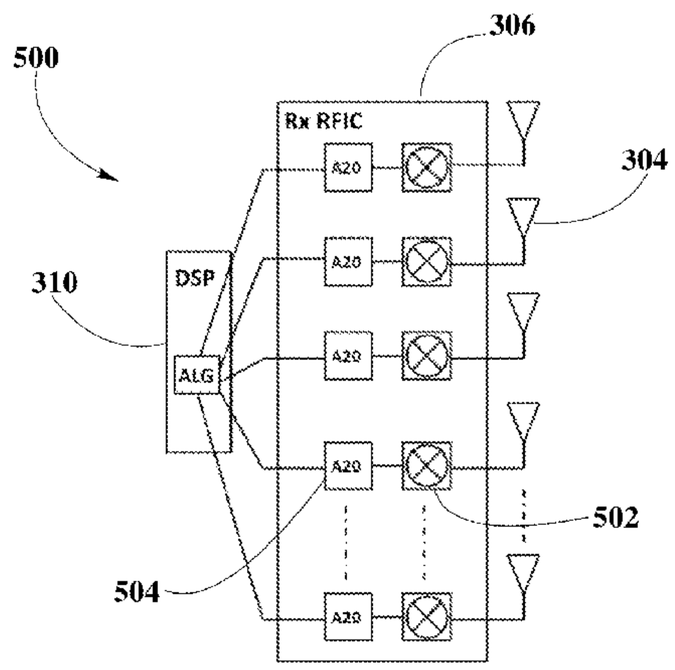
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(57) **ABSTRACT**

An enhanced transmitter for wireless power transmission is disclosed. The transmitter may be able to transmit radio frequency (RF) waves or pockets of energy for charging or powering an electronic device. The transmitter may include antenna element arrangements for receiving RF waves from a plurality of wireless sources and process them using a dedicated RF integrated circuit (RFIC) and set of antenna elements for receiving RF input signals from a plurality of wireless power sources. A digital signal processor (DSP) may be used to control reception using the dedicated RFIC and antenna elements of reception and to control transmission of wireless power selecting the transmitting RFICs and configuration of antenna elements to send RF waves or pockets of energy to a wireless receiver. The frequency of RF waves received may be sampled through a down converter array and line addressing devices to send the signals received to a micro-controller including a proprietary algorithm which control switching and processing necessary for faster and enhanced wireless power transmission, thus improving transmission efficiency.

20 Claims, 5 Drawing Sheets



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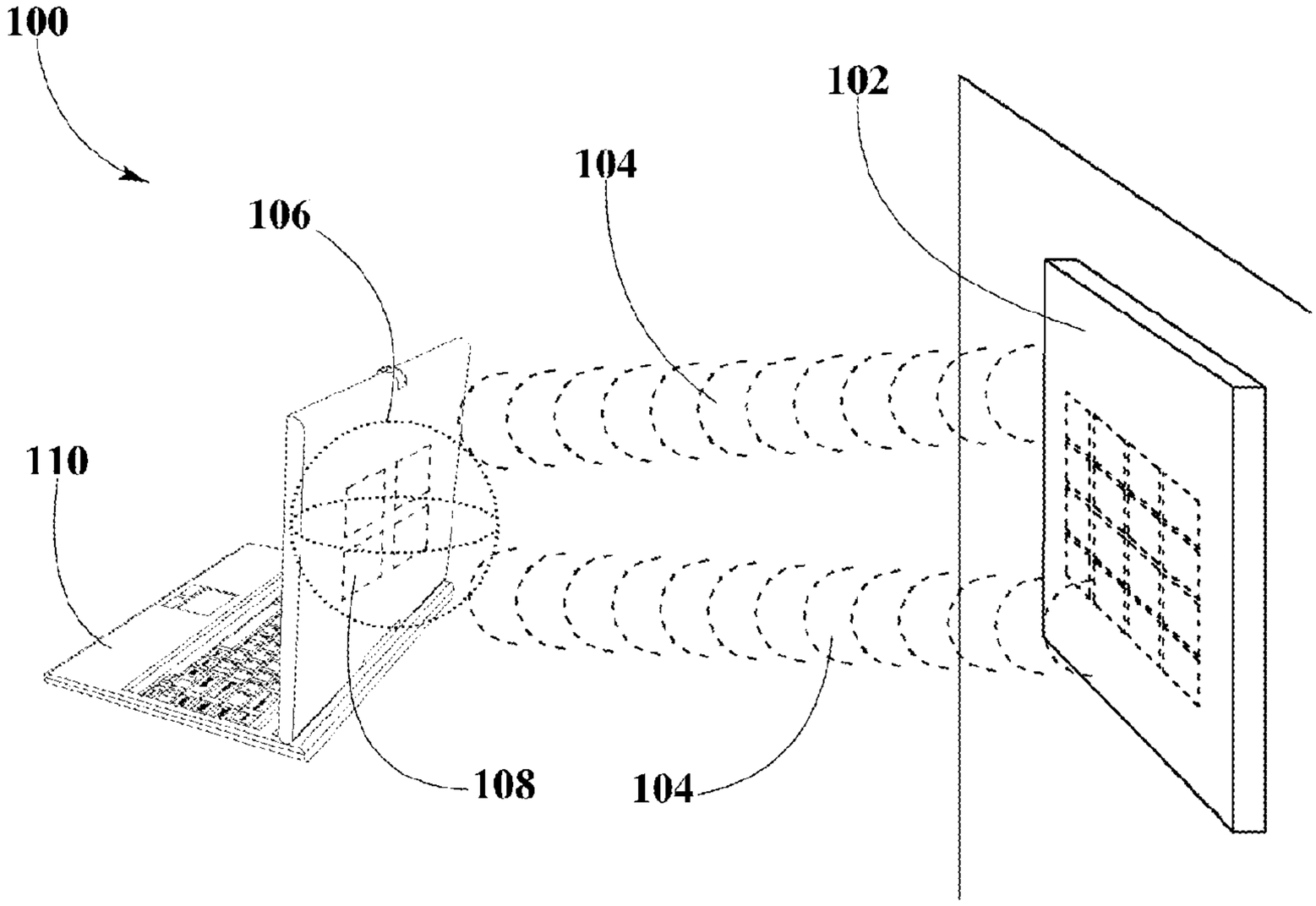


FIG. 1

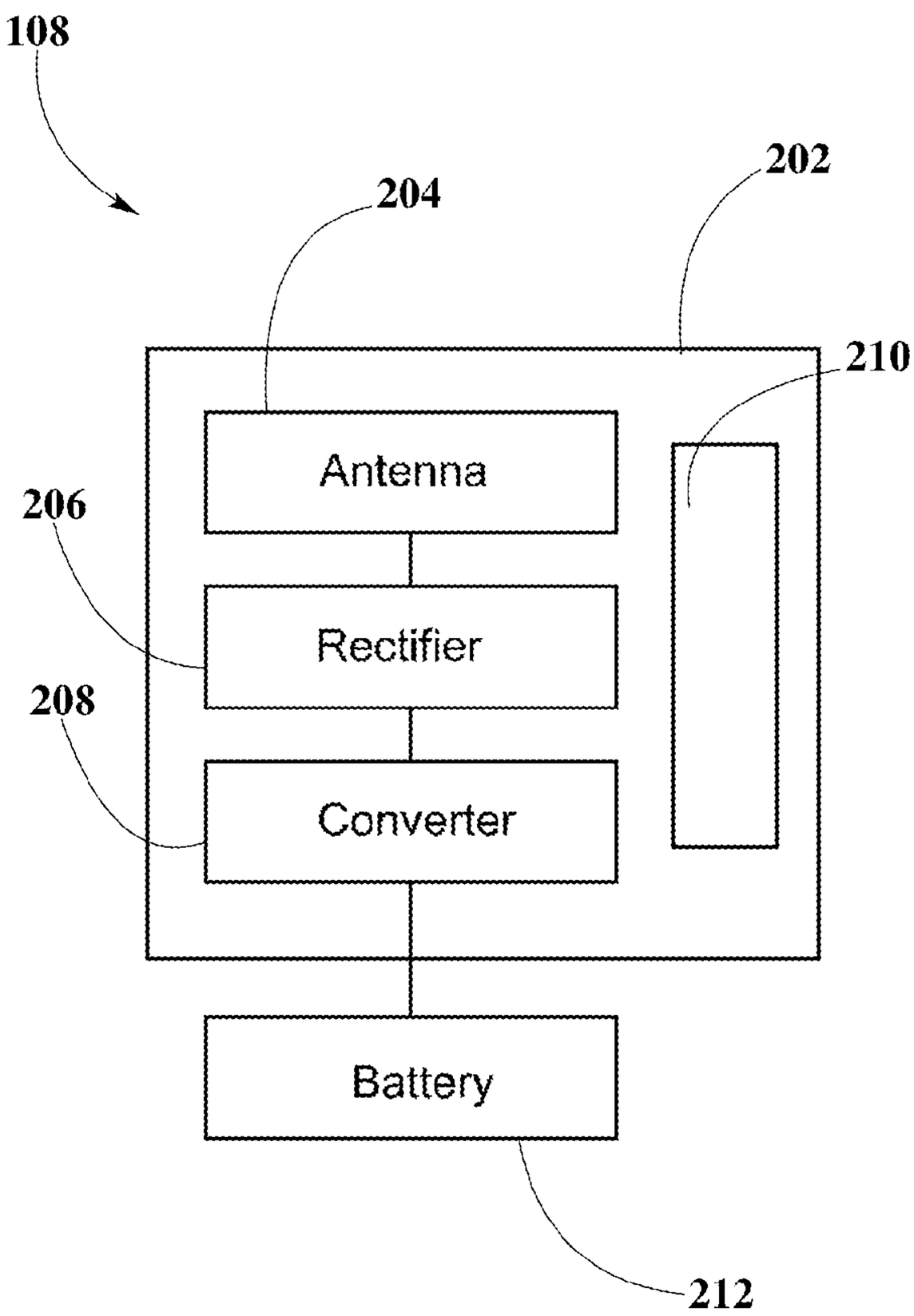

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206
Rectifier
208
Converter
Battery
212

FIG. 2

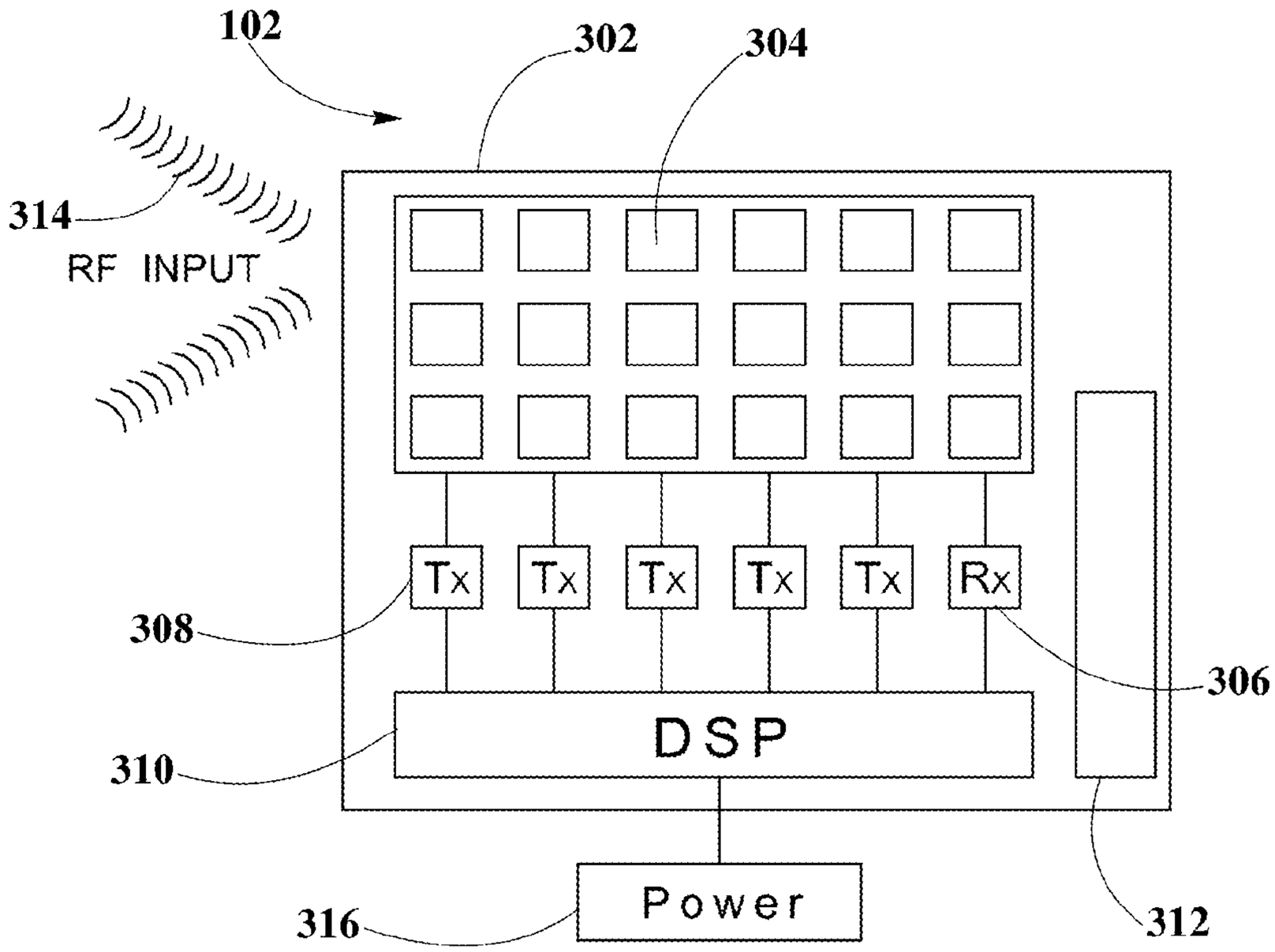

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FIG. 3

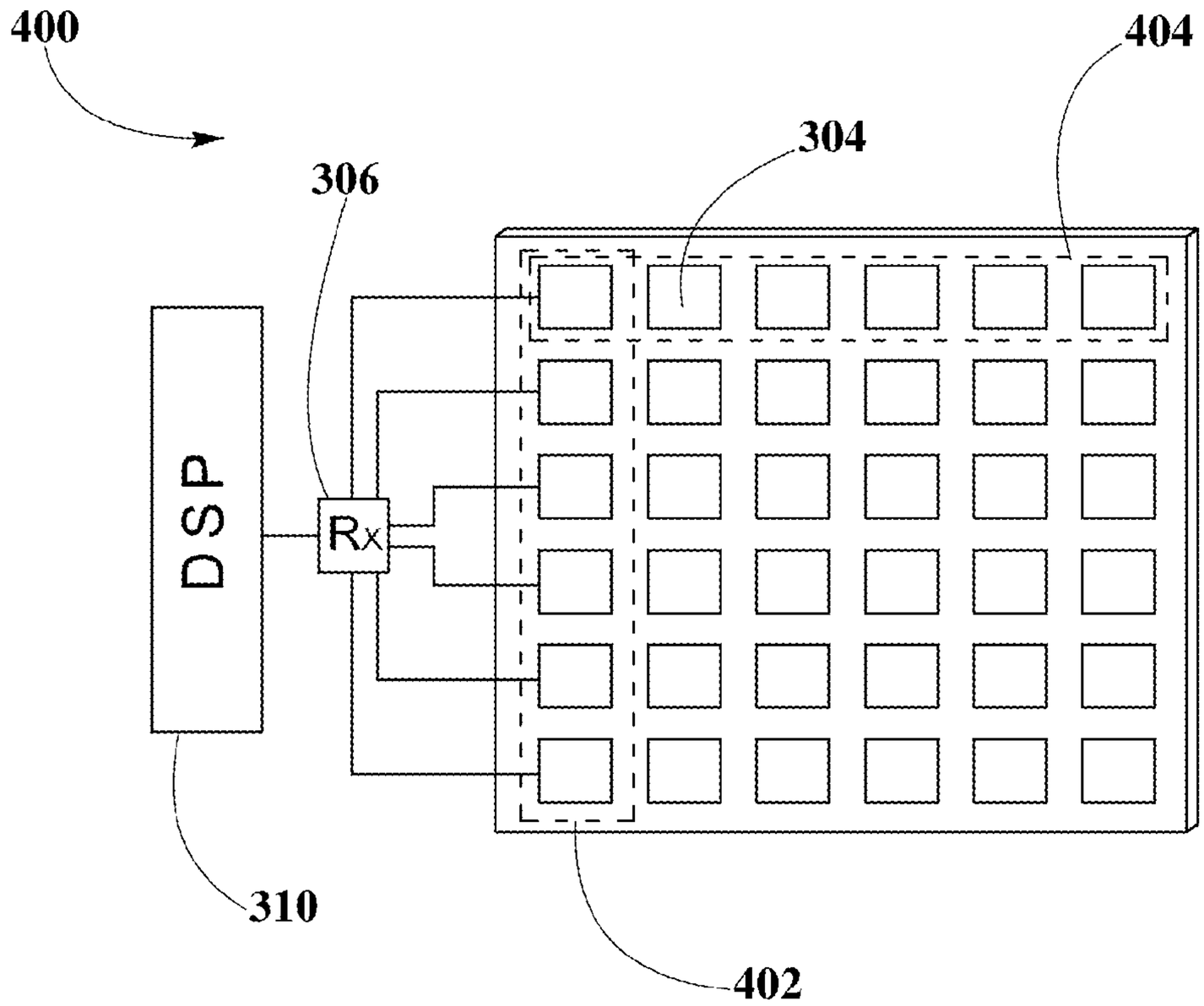


FIG. 4

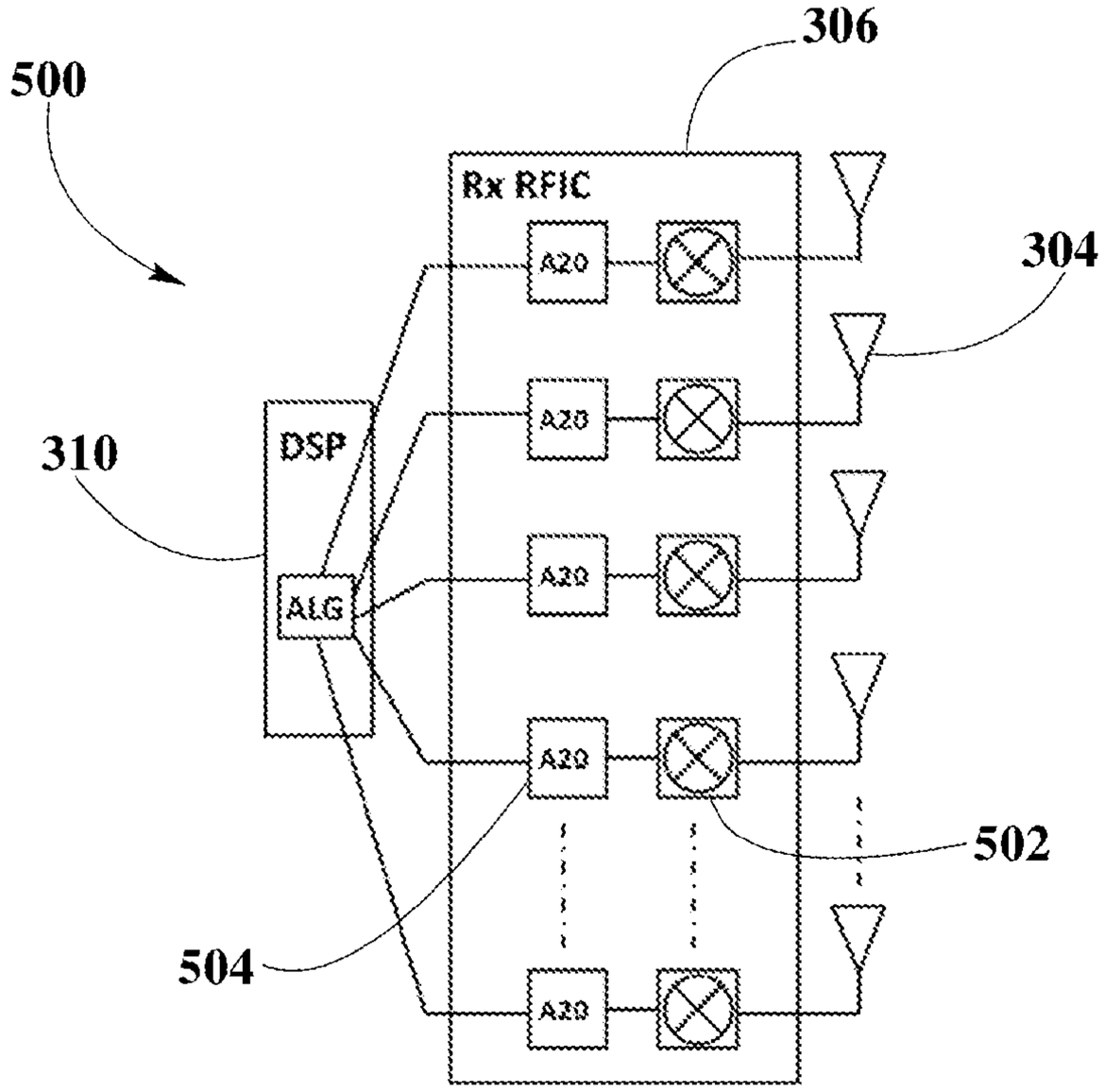


FIG. 5

ENHANCED TRANSMITTER USING FREQUENCY CONTROL FOR WIRELESS POWER TRANSMISSION

CROSS-REFERENCE TO RELATED APPLICATIONS

The present disclosure is related to U.S. non-provisional patent application DWV-3DPF-010 entitled "Methodology for Pocket-forming"; DWV-3DPF-015 entitled "Method for 3 Dimensional Pocket-forming"; DWV-3DPF-027 entitled "Receivers for Wireless Power Transmission"; DWV-3DPF-029 entitled "Transmitters for Wireless Power Transmission" invented by Michael A. Leabman; and ENG-SYHW-001 entitled "Enhanced Receiver for Wireless Power Transmission" invented by Jason Petras and Michael A. Leabman, each of which are incorporated by reference in their entireties.

BACKGROUND

Field of the Disclosure

The present disclosure relates generally to wireless power transmission, and more specifically, to a transmitter apparatus which transmits wireless power at high power transmission efficiency to power or charge electronic devices.

Background Information

A plurality of electronic devices are powered via rechargeable batteries. Such devices include smartphones, portable gaming devices, tablet computers, portable music players, laptop computers, computer peripheral devices, communication devices (e.g., Bluetooth devices), digital cameras, and hearing aids, amongst others. While battery technology has improved, battery-powered electronic devices increasingly require and consume greater amounts of power, thereby often requiring recharging. Rechargeable devices are often charged via wired connections through cables or other similar connectors that are physically connected to a power supply.

Wireless charging technology has been developed and used for electronic devices in an effort to solve problems presented by wired charging solutions, such as contamination of contact terminals and moisture preventing the appropriate charging of the battery in the electronic device. Wireless charging systems may be capable of transferring power in free space and provide power to electronic devices or can be used to charge rechargeable electronic devices. Wireless power transmission is performed through a transmitter and a receiver coupled to the electronic device to be charged. The receive antenna collects power from the transmitter and rectifies it for charging the battery.

Wireless power transmission (WPT) using radio frequency (RF) waves has been enabled in a plurality of applications, such as power transmission from space to earth and microwave-powered aircraft; powering of devices using an inductive resonance coupling scheme that makes use of near-field coupling between two magnetic resonators; and development of antenna arrays to harvest very low power levels from an RF transmitter located within a very short distance; amongst other applications.

During WPT using RF waves, power losses occur due to factors, such as RF-to-direct-current (RF-DC) conversion, hardware configuration and control logic for transmission, and RF propagation, amongst others. Recent developments have reduced losses from RF-DC conversion and spatial beam-forming improving the RF propagation efficiency.

Notwithstanding developments in current art, there is still a gap between existing technologies and practical WPT. Specifically, reliability in charging portable devices in complex environments of everyday life, efficient wireless power transmission, safety assurance, and cost, size and weight reduction of components for a wireless power transmission system.

As such, there is a need for a wireless power transmitter which addresses the previously mentioned limitations and more particularly, capable of transmitting wireless power with hardware components of lower cost and compactness which can provide high power efficiency.

SUMMARY OF THE INVENTION

An enhanced transmitter apparatus for transmitting wireless power or voltage from a plurality of received radio frequency (RF) signals is disclosed. The transmitter may deliver wireless power or voltage to a receiver apparatus which may extract and convert the transmitted RF waves in power or voltage for charging or powering an electronic device.

According to embodiments, it is an object of the present disclosure to provide an enhanced design for wireless power transmission transmitters of a discrete and low-cost system configuration and a plurality of power transfer control schemes for enhanced power efficiency transmission of a plurality of received RF waves to be transmitted to a wireless receiver.

The enhanced wireless power transmitter may be designed in accordance with a plurality of transmitter arrangements which may be employed for wireless transmission using suitable power transmission techniques. In present disclosure, suitable power transmission technique may preferably be the pocket-forming power transmission technique.

Accordingly, in an embodiment, a transmitter including a plurality of antenna elements may generate RF signals using a plurality of radio frequency integrated circuit (RFIC) which may be driven by one or more microcontrollers or digital signal processor (DSP) controllers. Wireless transmitters may receive power from a power source, which may provide power levels required for transmission of RF signals to the wireless receiver, which may be integrated in the electronic device.

In an another aspect of present disclosure, wireless power transmission may be enabled with a plurality of transmission configurations and/or sets of the antenna elements and RFICs which may be employed depending on the location from which wireless RF signals may be received and the position of the wireless receiver in the electronic device to be powered or charged. A proprietary algorithm residing in a micro-controller may control the operation of a set/configuration of dedicated antenna elements and a receiving (Rx) RFIC, which may be specifically designed for reception of RF input signals and which may include a plurality of hardware components for sampling and down-converting the received RF input signals to be transmitted to a wireless power receiver. Additionally, same micro-controller may control a set of transmitting (Tx) RFICs of different design and components as those used in the Rx RFIC, as well as a plurality of antenna elements for the transmission of wireless power RF signals to the wireless receiver in a faster manner, thus enhancing the power transmission efficiency.

In yet another aspect, the single Rx RFIC may be designed to provide the proper down-conversion and processing/sampling of received RF signals for the DSP con-

troller to enable the mode of transmission configuration with the appropriate set of Tx RFICs and antenna elements, using a reduced instruction set computing architecture of an ARM micro-processor in the micro-controller. The enhanced wireless power transmitter may provide a faster way of receiving/transmitting signals at same or higher frequency level as the frequency of RF input signals. The DSP or micro-controller in the enhanced wireless power transmitter may update control signals for the dedicated Rx RFIC up to 1,000 times/sec depending on duration of received signals, which may be as fast as 10 μsec.

The use of an ARM micro-processor may reduce cost, heat and power use, as it may be desirable for electronic devices to be powered or charged using wireless power transmission. The instruction set architecture of the ARM micro-processor may allow higher processing power and energy efficiency for the micro-controller in the enhanced wireless power transmitter.

Notwithstanding developments, the enhanced wireless power transmitter of present disclosure may address the existing gap between current technologies and practical wireless power transmission, specifically, in reliability in powering or charging portable devices in complex environments, efficient wireless power transmission, safety assurance, and cost, size and weight reduction of components for a wireless power transmission system.

Numerous other aspects, features and benefits of the present disclosure may be made apparent from the following detailed description taken together with the drawing figures.

BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure can be better understood by referring to the following figures. The components in the figures are not necessarily to scale, emphasis instead being place upon illustrating the principles of the disclosure. In the figures, reference numerals designate corresponding parts throughout the different views.

FIG. **1** illustrates wireless power transmission using pocket forming, according to an embodiment.

FIG. **2** depicts a block diagram of a receiver which may be used for wireless powering or charging one or more electronic devices, according to an embodiment.

FIG. **3** shows a block diagram of an enhanced wireless power transmitter which may be used for wireless power transmission, according to an embodiment.

FIG. **4** represents a transmitter arrangement of antenna elements which may be coupled to a dedicated receiving radio frequency integrated circuit (RFIC), according to an embodiment.

FIG. **5** illustrates a block diagram of a dedicated receiving RFIC in an enhanced wireless power transmitter, according to an embodiment.

DETAILED DESCRIPTION

The present disclosure is here described in detail with reference to embodiments illustrated in the drawings, which form a part here. Other embodiments may be used and/or other changes may be made without departing from the spirit or scope of the present disclosure. The illustrative embodiments described in the detailed description are not meant to be limiting of the subject matter presented here.

Definitions

As used here, the following terms may have the following definitions:

"Wireless device" refers to any electronic device able to communicate using one or more suitable wireless technologies. Suitable devices may include client devices in wireless networks and may be part of one or more suitable wireless technologies, including Wi-Fi and Bluetooth, amongst others.

"Wireless transmitter" refers to a device, including a chip which may generate two or more RF signals, at least one RF signal being phase shifted and gain adjusted with respect to other RF signals substantially, all of which pass through one or more RF antenna such that focused RF signals are directed to a target.

"Wireless receiver" refers to a device including at least one antenna element, at least one rectifying circuit and at least one power converter, which may utilize pockets of energy for powering, or charging a wireless device.

"Pocket-forming" may refer to generating two or more RF waves which converge in 3-d space, forming controlled constructive and destructive interference patterns.

"Adaptive pocket-forming" may refer to dynamically adjusting pocket-forming to regulate power on one or more targeted receivers.

DESCRIPTION OF THE DRAWINGS

An enhanced transmitter apparatus for transmitting wireless power or voltage from a plurality of received radio frequency (RF) signals is disclosed. The transmitter may deliver wireless power or voltage to a receiver apparatus which may extract and convert the transmitted RF waves in power or voltage for charging or powering an electronic device.

Wireless Power Transmission System Configuration

FIG. **1** illustrates a wireless power transmission **100** using pocket-forming. A transmitter **102** may transmit controlled Radio Frequency (RF) waves **104** which may converge in 3-d space. These RF waves **104** may be controlled through phase and/or relative amplitude adjustments to form constructive and destructive interference patterns (pocket-forming). Pockets of energy **106** may be formed at constructive interference patterns and can be 3-dimensional in shape, while null-spaces may be generated at destructive interference patterns. A receiver **108** may then utilize pockets of energy **106** produced by pocket-forming for charging or powering a cordless electronic device **110**, for example, a smartphone, a tablet, a laptop computer (as shown in FIG. **1**), a music player, an electronic toy, and the like. In some embodiments, there can be multiple transmitters **102** and/or multiple receivers **108** for powering various electronic devices **110** at the same time. In other embodiments, adaptive pocket-forming may be used to regulate the power transmitted to electronic devices **110**.

Wireless Power Transmission Receiver Hardware Configuration

FIG. **2** depicts the block diagram of receiver **108** which can be used for wireless powering or charging one or more electronic devices **110** as exemplified in wireless power transmission **100**. According to some aspects of this embodiment, receiver **108** may operate with the variable power source generated from transmitted RF waves **104** to deliver constant and stable power or energy to electronic device **110**. In addition, receiver **108** may use the variable power source generated from RF waves **104** to power up electronic components within receiver **108** for proper operation.

Receiver **108** may include a housing **202** where at least one antenna element **204**, one rectifier **206**, one power converter **208** and a communications component **210** may be

included. Housing **202** can be made of any suitable material which may allow for signal or wave transmission and/or reception, for example plastic or hard rubber. Housing **202** may be an external hardware that may be added to different electronic equipment, for example in the form of cases, or may be embedded within electronic equipment as well. Antenna element **204** may include suitable antenna types for operating in frequency bands similar to the bands for transmitter **102** from FIG. **1**.

Antenna element **204** may include vertical or horizontal polarization, right hand or left hand polarization, elliptical polarization, or other suitable polarizations, as well as suitable polarization combinations. Using multiple polarizations may be beneficial in devices where there may not be a preferred orientation during usage or whose orientation may vary continuously through time, for example a smartphone or portable gaming system. On the contrary, for devices with well-defined orientations, for example a two-handed video game controller, there might be a preferred polarization for antennas which may dictate a ratio for the number of antennas of a given polarization. Suitable antenna types may include patch antennas with heights from about 1/24 inches to about 1 inch and widths from about 1/24 inches to about 1 inch. Patch antennas may have the advantage that polarization may depend on connectivity, i.e., depending on which side the patch may be fed, the polarization may change. This may further prove advantageous as a receiver, such as receiver **108**, may dynamically modify its antenna polarization to optimize wireless power transmission.

Rectifier **206** may include diodes or resistors, inductors or capacitors to rectify the alternating current (AC) voltage generated by antenna element **204** to direct current (DC) voltage. Rectifier **206** may be placed as close as is technically possible to antenna element **204** to minimize losses. After rectifying AC voltage, DC voltage may be regulated using power converter **208**. Power converter **208** can be a DC-DC converter which may help provide a constant voltage output, regardless of input, to an electronic device, or as in this embodiment to a battery **212**. Typical voltage outputs can be from about 5 volts to about 10 volts. In some embodiments, power converter **208** may include electronic switched mode DC-DC converters which can provide high efficiency. In such a case, a capacitor (not shown) may be included before power converter **208** to ensure that sufficient current is provided for the switching device to operate. When charging an electronic device **110**, for example a phone or laptop computer, initial high currents, which can break-down the operation of an electronic switched mode DC-DC converter, may be required. In such a case, a capacitor (not shown) may be added at the output of receiver **108** to provide the extra energy required. Afterwards, lower power may be provided, for example 1/80 of the total initial power while still having the phone or laptop to build-up charge. Lastly, a communications component **210** may be included in receiver **108** to communicate with a transmitter or other electronic equipment.

Different antenna, rectifier or power converter arrangements may be possible for a receiver **108**.

Enhanced Wireless Power Transmitter Hardware Configuration

FIG. **3** depicts the block diagram of an enhanced wireless power transmitter **102** which may be used in wireless power transmission **100**. Transmitter **102** may include a housing **302**, at least two or more antenna elements **304**, at least one receiving (Rx) RF integrated circuit (RFIC) **306**, a plurality of transmitting (Tx) RF integrated circuit (RFIC) **308**, at least one digital signal processor (DSP) or micro-controller **310**, and one communications component **312**. Micro-controller **310** may be included into an independent base station or into the transmitter **102**.

RF input signals **314** may be produced using a power source **316** and a local oscillator chip (not shown) using a suitable piezoelectric material, or may be from other wireless sources (not shown), such as from a frequency chip, Bluetooth, and Wi-Fi.

Housing **302** may be made of any suitable material which may allow for signal or wave transmission and/or reception, for example plastic or hard rubber. Antenna elements **304** may include suitable antenna types for operating in frequency bands such as 900 MHz, 2.5 GHz or 5.8 GHz as these frequency bands conform to Federal Communications Commission (FCC) 47 CFR Part 18—Industrial, Scientific, and Medical Equipment. Antenna elements **304** may include vertical or horizontal polarization, right hand or left hand polarization, elliptical polarization, or other suitable polarizations as well as suitable polarization combinations. Suitable antenna types may include, for example, patch antennas with heights from about 1/8 of an inch to about 8 inches and widths from about 1/8 of an inch to about 6 inches. Other antenna elements **304** types that may be used include meta-materials based antennas, dipole antennas, and planar inverted-F antennas (PIFAs), amongst others.

Transmitter **102** may include a plurality of arrangements in which antenna elements **304** may be connected to dedicated Rx RFIC **306** or to Tx RFICs **308**. Arrangements may include different configurations, such as a dedicated row or column of antenna elements **304** coupled to Rx RFIC **306**, and at least two or more rows or columns of antenna elements **304** coupled to Tx RFICs **308**. Rx RFIC **306** may include a proprietary chip for adjusting phases and/or relative magnitudes of frequency of RF input signals **314** collected from the dedicated set/configuration antenna elements **304** for reception of RF input signals **314**. Rx RFIC **306** may be designed to include hardware and logic elements specifically dedicated for reception and processing of RF input signals **314**, which are not included as components of TX RFICs **308**.

In present embodiment of the enhanced wireless transmitter **102**, **24** RFICs may be connected to 200 antenna elements **304** and configured to allow operation of Rx RFIC **306** as the dedicated receiver of RF input signals **314** operatively coupled to a dedicated column of at least two or more antenna elements **304**, depending on the transmitter **102** configuration and operation, for example, eight antenna elements **304**. The remaining 23 Tx RFICs **308** may be operatively coupled to a set/configuration of antenna elements **304**, other than those used to receive RF input signals **314** by Rx RFIC **306**. Tx RFICs **308** may be coupled to transmitting antenna elements **304** depending on control signals from micro-controller **310**.

Micro-controller **310** may include a proprietary algorithm to implement control of Rx RFIC **306** and to allow operation of Rx RFIC **306** using a switching control which enables monitoring of reception separately from transmission without overlapping in the operation of Rx RFIC **306** and Tx RFICs **308**. RF input signals **314** may be sampled at once after Rx RFIC **306** may be allowed to receive by switching control in micro-controller **310**.

After the operation of Rx RFIC **306**, Tx RFICs **308** may implement wireless power transmission **100** to receiver **108**. Micro-controller **310** may select a column of antenna elements **304**, a row of antenna elements **304**, or any interpolation of arrangement of antenna elements **304** to couple

with Tx RFICs **308**, depending on location from which wireless power is to be transmitted.

Micro-controller **310** may also process information sent by receiver **108** through communications component **312** for determining optimum times and locations for pocket-forming. Communications component **312** may be based on standard wireless communication protocols which may include Bluetooth, Wi-Fi or ZigBee. In addition, communications component **312** may be used to transfer other information, such as an identifier for the device or user, battery level, location, or other such information. Other communications component **312** may be possible, including radar, infrared cameras or sound devices for sonic triangulation of electronic device **110** position.

Receiving Antenna Arrangement of an Enhanced Wireless Power Transmitter

FIG. **4** represents a transmitter arrangement **400** of antenna elements **304** which may be coupled to dedicated Rx RFICs **306**, according to an embodiment.

Depending on the location from which RF input signals **314** may be received and information sent by receiver **108** to be processed by communications component **312** regarding determination of optimum times and locations for pocket-forming, which may enhance efficiency of wireless power transmission **100**, micro-controller **310** may select Tx RFICs **308** and the arrangement of antenna elements **304** to maximize the transmission operation of transmitter **102**. As seen in FIG. **4**, micro-controller **310** may send switching control signals to Rx RFIC **306** coupled to either antenna column **402** or antenna row **404** to include the antenna elements **304** receiving RF input signals **314**, as described in FIG. **3**. After reception and processing of signals by Rx RFIC **306**, the remaining antenna elements **304** may be coupled to Tx RFICs **308** using a plurality of configurations of antenna elements **304** as a result of an interpolation step which may be performed by micro-controller **310** to control operation of Tx RFICs **308** using the ARM micro-processor in micro-controller **310** to enhance wireless power transmission performance of transmitter **102**, directing transmission of wireless power to the appropriate location.

Antenna elements **304** to connected to Rx RFIC **306** may reduce processing requirement and may increase control over pocket-forming, allowing multiple pocket-forming and a higher granular pocket-forming with less load over micro-controller **310**; thus, a higher response of higher number of multiple pocket-forming may be allowed for transmission. Furthermore, multiple pocket-forming may charge a higher number of receivers **108** and may allow a better trajectory to such receivers **108** to provide a less expensive embodiment.

Integrated Circuit Configuration and Operation of a Receiving RFIC

FIG. **5** illustrates a block diagram **500** of Rx RFIC **306** in an enhanced wireless power transmitter **102**, according to an embodiment.

RF input signals **314** received by antenna elements **304** dedicated for reception and operatively coupled to Rx RFIC **306**, depending on the location from which they may be radiated to transmitter **102**, enable micro-controller **310**, as described in FIG. **4**. RF input signal **314** may then be subject to frequency sampling by an array of down-converters **502** included in Rx RFIC **306** in which the range of frequencies of RF input signals **314** of about 2.4 GHz or about 5.6 GHz may be shifted into RF signals of a new frequency range.

Down-converters **502** may include a local oscillator (not shown) providing a signal of pre-determined frequency to mix with the RF input signals **314** creating a sum heterodyne and a difference heterodyne from which one of the heterodyne may be filtered to provide the desired output frequency. In present embodiment a signal of about 5.8 GHz may be down-converted to an output signal of about 5.0 GHz. Output signal of 5.0 GHz from down-converters **502** may then be fed to addressing lines (A20) **504** at 10 MHz for processing by micro-controller **310**. Enhanced wireless power transmitter **102** may be receiving at one frequency, for example 2.4 GHz, and transmitting at a higher frequency, for example 5.7 GHz.

Micro-controller **310** may be enabled to send control signals of about 1 msec or about 100 μsec to Rx RFIC **306** and depending on how fast the RF input signals **314** may being received, control may be enabled every msec or about 10 times/sec for 1 msec. If RF input signals **314** may be constantly received, for example every 10 μsec, updating may be implemented to about 1,000 times/sec.

In micro-controller **310**, the proprietary algorithm may enable sampling of the incoming signals from each A20 **504** and may use an ARM micro-processor (not shown) to drive the required Tx RFICs **308** coupled to the determined set/configuration of antenna elements **304** to transmit wireless power to the appropriate location of receiver **108**. The use of an ARM micro-processor may reduce cost, heat and power use, as it may be desirable for electronic devices **110** to be powered or charged using wireless power transmission **100**. The instruction set architecture of the ARM micro-processor may allow higher processing power and energy efficiency for micro-controller **310**.

While various aspects and embodiments have been disclosed, other aspects and embodiments may be contemplated. The various aspects and embodiments disclosed here are for purposes of illustration and are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

What is claimed is:

1. An apparatus for controlling transmission of wireless signals suitable for charging devices, comprising:

a controller;

at least one receiving circuit, operatively coupled to the controller;

a plurality of transmitting circuits, operatively coupled to the controller;

a communication component coupled to the controller and configured to communicate with a receiver to identify a location for forming a controlled constructive interference pattern; and

an antenna array comprising a plurality of antenna elements, wherein a first portion of the plurality of antenna elements are respectively coupled to the at least one receiving circuit and a second portion of the plurality of antenna elements are respectively coupled to the plurality of transmitting circuits;

wherein:

the at least one receiving circuit is configured to receive incoming RF signals from the receiver using the first portion of the plurality of antenna elements,

the controller is configured to:

(i) sample and process the incoming RF signals, and

(ii) control operation of the plurality of transmitting circuits so as to generate outgoing RF signals having a frequency that is higher than a frequency of the incoming RF signals to form the controlled constructive interference pattern proximate to the location, and

the plurality of transmitting circuits is configured to:

(i) generate the outgoing RF signals having the frequency that is higher than the frequency of the incoming RF signals and

(ii) cause the second portion of the plurality of antenna elements to transmit the outgoing RF signals having the frequency that is higher than the frequency of the incoming RF signals.

2. The apparatus of claim **1**, wherein the controller is configured to control operation of the plurality of transmitting circuits by selecting at least some of the second portion of the plurality of antenna elements for concentrating transmission of the outgoing RF signals.

3. The apparatus of claim **2**, wherein the selected at least some of the second portion of the plurality of antenna elements concentrate transmission of the outgoing RF signals by wirelessly broadcasting the outgoing RF signals to form the controlled constructive interference pattern proximate to the location.

4. The apparatus of claim **1**, wherein the controller is selected from the group consisting of: a microcontroller, a digital signal processor, and an ARM microprocessor.

5. The apparatus of claim **1**, wherein the at least one receiving circuit is configured to down-convert a range of the frequency of the incoming RF signals.

6. The apparatus of claim **5**, wherein the at least one receiving circuit is configured to adjust at least one of a phase and a relative magnitude of the frequency of the incoming RF signals.

7. The apparatus of claim **1**, wherein the plurality of antenna elements comprises patch antennas.

8. The apparatus of claim **1**, wherein the communication component is configured to receive information for processing by the controller to optimize a time and one or more locations for transmitting the outgoing RF signals.

9. An apparatus for controlling transmission of wireless signals suitable for charging devices, comprising:

a controller;

one or more receiving circuits configured to receive incoming RF signals from a receiver;

a communication component coupled to the controller and configured to communicate with the receiver to identify a location for forming a controlled constructive interference pattern; and

an antenna array comprising a plurality of antenna elements, wherein a first portion of the plurality of antenna elements are respectively coupled to the one or more receiving circuits and a second portion of the plurality of antenna elements are respectively coupled to a plurality of transmitting circuits;

wherein the controller is operatively coupled to the one or more receiving circuits and the plurality of transmitting circuits, and

the controller is configured to:

(i) send switching signals to the one or more receiving circuits to select a sub-portion of the first portion of antenna elements to receive the incoming RF signals,

(ii) process the incoming RF signals to obtain a frequency thereof, and

(iii) control operation of the plurality of transmitting circuits so as to generate outgoing RF signals having a frequency that is higher than the frequency of the incoming RF signals to form the controlled constructive interference pattern proximate to the location, and the plurality of transmitting circuits is configured to:

(i) generate the outgoing RF signals having the frequency that is higher than the frequency of the incoming RF signals and

(ii) cause the second portion of the plurality of antenna elements to transmit the outgoing RF signals having the frequency that is higher than the frequency of the incoming RF signals.

10. The apparatus of claim **9**, wherein the sub-portion comprises at least one of a row or a column of the plurality of antenna elements in the antenna array.

11. The apparatus of claim **9**, wherein the controller is configured to control operation of the transmitting circuit by selecting at least some of the second portion of the plurality of antenna elements for concentrating transmission of the outgoing RF signals.

12. The apparatus of claim **11**, wherein the selected at least some of the second portion of the plurality of antenna elements concentrate transmission of the outgoing RF signals by wirelessly broadcasting the outgoing RF signals to form the controlled constructive interference pattern proximate to the location.

13. The apparatus of claim **9**, wherein the controller is selected from the group consisting of: a microcontroller, a digital signal processor, and an ARM microprocessor.

14. The apparatus of claim **9**, wherein the receiving circuit is configured to down-convert a range of the frequency of the incoming RF signals.

15. The apparatus of claim **14**, wherein the receiving circuit is configured to adjust at least one of a phase and a relative magnitude of the frequency of the incoming RF signals.

16. The apparatus of claim **9**, wherein the plurality of antenna elements comprises patch antennas.

17. The apparatus of claim **9**, wherein the communications component is configured to receive information for processing by the controller to optimize a time and one or more locations for transmitting the outgoing RF signals.

18. A method for providing wireless power, comprising:

receiving, by a first portion of antennas in an antenna array of a transmitter coupled to a receiver circuit of the transmitter, incoming RF signals;

receiving, by a communication component of the transmitter, from a receiver, a communication signal containing a location associated with the receiver;

generating, by a transmitting circuit of the transmitter and for transmission by a second portion of antennas in the antenna array, outgoing RF signals in accordance with the location associated with the receiver,

utilizing a controller, which is operatively coupled to the receiver circuit, the transmitting circuit, and the communication component, of the transmitter to:

(i) sample and process the incoming RF signals and

(ii) control operation of the transmitting circuit so as to generate the outgoing RF signals having a frequency that is higher than a frequency of the incoming RF signals to form a controlled constructive interference pattern proximate to the location associated with the receiver; and

(iii) cause the second portion of antennas of the antenna array of the transmitter to transmit the outgoing RF signals having the frequency that is higher than the frequency of the incoming RF signals to form the controlled constructive interference pattern proximate to the location associated with the receiver.

19. The method of claim **18**, wherein generating, by the transmitting circuit, the outgoing RF signals includes generating at least two outgoing RF signals.

20. The method of claim 19, further comprising:

phase shifting and gain adjusting one of the at least two outgoing RF signals with respect to the other of the at least two outgoing RF signals to generate the controlled constructive interference pattern proximate to the location associated with the receiver.

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