Claims

1. A power transmitter, comprising:

(i) a signal generator operable to generate an electrical signal comprising an adjustable frequency and duty cycle;

(ii) one or more first transmitter electrodes arranged to be electrically coupled to a living being body for transmission of the electrical signal via the living being body to at least one power receiver;

(iii) one or more second transmitter electrodes arranged to be electrically coupled to the living being body, and operable to receive an indication of power received by the at least one power receiver via the living being body; and

(iv) a controller configured to control the signal generator to adjust the frequency and duty cycle of the electrical signal in response to the indication of power received.

2. The power transmitter according to claim 1,

wherein the electrical signal comprises a plurality of components,

the one or more first electrodes are arranged to be electrically coupled to the living being body for transmission of each of the plurality of components of the electrical signal via the living being body to a corresponding one of a plurality of power receivers,

the one or more second electrodes are operable to receive an indication of power received by each of the plurality of power receivers via the living being body, and

the controller is configured to control the signal generator to adjust a component frequency and a component duty cycle of each of the plurality of components of the electrical signal in response to the indication of power received by the corresponding power receiver.

3. The power transmitter according to claim 1 or 2, wherein the signal generator further comprises a power generating circuit including:

a voltage multiplier circuit arranged to receive an input supply voltage, the voltage multiplier circuit comprising a plurality of cascaded voltage multipliers arranged to generate corresponding multiplier output signals; and

a driving circuit configured to generate the electrical signal with a specific output voltage swing in direct response to the corresponding multiplier output signals, the specific output voltage swing being greater than the input supply voltage.

4. The power transmitter according to claim 3, wherein the corresponding multiplier output signals include a driver supply voltage, at least one intermediate biasing signal, and a plurality of clock signals for the driving circuit.

5. An energy transfer apparatus comprising:

(i) a power transmitter according to any one of claims 1 to 4; and

(ii) the at least one power receiver, comprising:

(a) one or more power receiver electrodes arranged to be electrically coupled to the living being body, the one or more power receiver electrodes operable to receive the transmitted electrical signal via the body;

(b) at least one rectifier for rectifying the transmitted electrical signal into at least one rectified electrical signal;

(c) a DC-DC converter operable to convert the at least one rectified electrical signal to generate a recovered power signal, wherein the DC-DC converter is operable to determine the power received by the at least one power receiver; and

(d) one or more data transmitter electrodes arranged to be electrically coupled to the living being body for transmission of the indication of the power received by the at least one power receiver to the power transmitter.

6. The energy transfer apparatus according to claim 5, wherein the one or more power receiver electrodes are further operable to receive a body-coupled ambient energy electrical signal via the body.

7. The energy transfer apparatus according to claim 6, wherein the at least one rectifier includes a first rectifier for rectifying the transmitted electrical signal into a first rectified electrical signal, the at least one power receiver further includes a second rectifier for rectifying the body-coupled ambient energy electrical signal into a second rectified electrical signal, and wherein the DC-DC converter is operable to convert the first rectified electrical signal and the second electrical signal concurrently to generate the recovered power signal.

8. The energy transfer apparatus according to any one of claims 5 to 7, wherein the at least one power receiver further comprises a controller, wherein the controller is arranged to adjust an inductor charging time of the DC-DC converter to enable an input power of the DC-DC converter to reach a maximum value.

9. The energy transfer apparatus according to any one of claims 5 to 8, wherein the DC-DC converter includes a power evaluation circuit and is operable between a load regulation mode for delivering regulated power to a load and a power evaluation mode for determining the power received by the power receiver.

10. The energy transfer apparatus according to claim 9, wherein the DC-DC converter is operable between the load regulation mode and the power evaluation mode responsive to a voltage level of the recovered power signal.

11. The energy transfer apparatus according to any one of claims 5 to 10, wherein the power received by the at least one power receiver is determined as a function of an inductor discharge time of the DC-DC converter.

12. The energy transfer apparatus according to any one of claims 5 to 11, wherein the power received by the at least one power receiver is determined as an average received power.

13. A method of transmitting electrical power via one or more first transmitter electrodes coupled to a body of a living being, the method comprising:

generating, by a signal generator having an adjustable frequency and duty cycle, an electrical signal;

receiving an indication of power received by at least one power receiver via one or more second transmitter electrodes coupled to the living being body; and

adjusting the frequency and duty cycle of the electrical signal in response to the indication of power received.

14. The method of transmitting electrical power according to claim 13, further comprising:

generating the electrical signal with a plurality of components, each component operable to transmit electrical power to a different power receiver of a plurality of power receivers;

receiving an indication of power received by each of the plurality of power receivers via the one or more second transmitter electrodes;

adjusting a component frequency and a component duty cycle of each of the plurality of components of the electrical signal in response to the indication of power received by the corresponding power receiver.

15. The method of transmitting electrical power according to claim 14,

further comprising time-division multiplexing the plurality of components to generate the electrical signal.

16. The method of transmitting electrical power according to any one of claims 13 to 15, further comprising:

receiving an input supply voltage at a voltage multiplier circuit, the voltage multiplier circuit comprising a plurality of cascaded voltage multipliers;

generating, by the plurality of cascaded voltage multipliers, corresponding multiplier output signals; and

generating the electrical signal with a specific output voltage swing in direct response to the corresponding multiplier output signals, the specific output voltage swing being greater than the input supply voltage.

17. The method of transmitting electrical power according to claim 16, wherein the corresponding multiplier output signals include a driver supply voltage, at least one intermediate biasing signal, and a plurality of clock signals for a driving circuit.

18. The method of transferring energy via a body of a living being, the method comprising:

transmitting, from a power transmitter, electrical power via one or more first transmitter electrodes coupled to the body of a living being according to a method of any one of claims 16 to 20;

receiving, at the power receiver, the electrical signal via one or more power receiver electrodes coupled to the living being body;

rectifying the electrical signal into at least one rectified electrical signal;

converting the at least one rectified electrical signal to generate a recovered power signal;

determining the power received by the power receiver; and

transmitting the indication of the power received to the power transmitter via one or more data transmitter electrodes coupled to the living being body.

19. The method of transferring energy via a body of a living being according to claim 18, comprising

converting, at a DC-DC converter, the at least one rectified electrical signal to generate the recovered power signal, and

adjusting an inductor charging time of the DC-DC converter to enable an input power of the DC-DC converter to reach a maximum value.

20. The method of transferring energy via a body of a living being according to claim 19, further comprising determining the power received by the power receiver at the DC-DC converter or determining the power received by the power receiver at the DC-DC converter as a function of an inductor discharge time of the DC-DC converter.