

CLAIMS

- 1 A receiver for wirelessly receiving power from a transmitter, the
receiver comprising a resonant receiver circuit having a plurality of coils operatively
5 coupled to a combining circuit,
wherein each coil, with the combining circuit, is arranged to receive power via
resonant inductive coupling, and
wherein the combining circuit is arranged to combine power received from the
plurality of coils for provision to an electric load.
- 10 2. The receiver of claim 1, wherein at least two coils of the plurality of
coils are orientated at different angles to each other.
3. The receiver of claim 1 or 2, wherein at least two coils of the plurality
15 of coils are configured for critical coupling at different distances to each other.
4. The receiver of any preceding claim, wherein the combining circuit
comprises a plurality of impedance elements, wherein the plurality of impedance
elements are connected together to combine power received from each of the
20 plurality of coils into a combined power signal that is provided to an output of the
combining circuit, and
wherein each coil is coupled to the output of the combining circuit by a
combination of impedance elements, the combination of impedance elements having
a characteristic impedance which combines together with that coil to form a resonant
25 circuit for receiving power via resonant inductive coupling.
5. The receiver of any preceding claim, wherein the combining circuit
comprises a plurality of power combiners, each power combiner having two input
ports coupled to an output port and being operable to provide at the output port a
30 combination of separate power signals received at both input ports, and
wherein the plurality of power combiners are connected together to
combine power received from each of the plurality of coils into a combined power
signal that is provided to an output of the combining circuit, and
wherein each power combiner has a characteristic impedance, and
35 wherein each coil is coupled to the output of the combining circuit by a combination
of power combiners having characteristic impedances which combine together with
that coil to form a resonant circuit for receiving power via resonant inductive coupling.
6. The receiver of claim 5, wherein the plurality of power combiners are
40 grouped into multiple stages including a first stage, wherein the number of first stage

power combiners matches the number of coils in the plurality of coils, and each first stage power combiner is associated with a different coil of the plurality of coils, and wherein each first stage power combiner has a first input port connected to a first end of its associated coil, and a second input port connected to a second end of its associated coil.

7. The receiver of claim 6, wherein the multiple stages include one or more further stages, and wherein, for each further stage, the number of power combiners in that further stage matches half the number of power combiners in an adjacent previous stage, and each power combiner in that further stage is associated with a different pair of power combiners from the adjacent previous stage, and each power combiner from the adjacent previous stage is only associated with a single power combiner from that further stage, and each power combiner in that further stage has a first input port connected to the output port of one of its associated pair of power combiners from the adjacent previous stage, and a second input port connected to the output port of the other of its associated pair of power combiners from the adjacent previous stage.

8. The receiver of any one of claims 5 to 7, wherein connections between the plurality of power combiners in the combining circuit are selected to minimise differences between the power signals provided at the first and second input ports of each power combiner.

9. The receiver of claim 8, when dependent on claim 7, wherein the power combiners from the adjacent previous stage are paired together based their average power output.

10. The receiver of any one of claims 5 to 9, wherein at least one of the power combiners is a Wilkinson power combiner.

11. The receiver of any one of claims 5 to 10, wherein at least one of the power combiners is formed from a microstrip electrical transmission line.

12. The receiver of any preceding claim, further comprising an electric load coupled to the combining circuit to receive power therefrom.

13. The receiver of claim 12, wherein the electric load comprises a rectifier to convert the power received from the combining circuit into a direct current (DC) signal.

14. The receiver of claim 13, wherein the electric load comprises an electrosurgical apparatus for generating and delivering electromagnetic energy into a treatment site around the receiver for treating biological tissue.

5 15. The receiver of claim 14, wherein the electrosurgical apparatus comprises:

a microwave power amplifier coupled to the rectifier for generating microwave electromagnetic energy from the DC signal, and

10 a transmission line coupled to the microwave power amplifier for delivering the microwave electromagnetic energy into biological tissue in the treatment site.

16. The receiver of claim 15, wherein the transmission line is arranged to have an impedance that matches an impedance of a target biological tissue in the treatment site.

15 17. The receiver of any one of claims 13 to 16, wherein the electric load comprises a sensor for generating an electrical signal based on an environment of the receiver, the sensor being operatively coupled to the rectifier so as to be powered by the DC signal, the sensor being operatively coupled to the combining circuit so as to provide the electrical signal thereto, and wherein each coil, with the combining circuit, provides a resonant transmitter circuit arranged to transmit the electrical signal via resonant inductive coupling.

20 18. The receiver of claim 17, wherein the electric load comprises a signal conditioning unit operatively coupled in-between the sensor and the combining circuit, the signal conditioning unit being operable to vary a characteristic of the electrical signal before transmission.

25 19. A capsule for ingestion by a patient, the capsule comprising a housing containing a receiver according to any preceding claim.

30 20. The capsule of claim 19, wherein a shape of the housing is substantially spherocylindrical, and wherein the plurality of coils are arranged in a substantially oval shape which follows an inside surface of the housing.

21. A wireless power transfer system comprising:
a transmitter for wirelessly transmitting power, the transmitter
comprising a resonant transmitter circuit having a coil arranged to transmit power
5 wirelessly via resonant inductive coupling, and
a receiver according to any one of claims 1 to 18, or a capsule of
claim 19 or 20, for wirelessly receiving power from the transmitter.