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Method for wireless transmission of a power

The invention relates to a method for wireless transmission of a power between a transmitter and a receiver, comprising a power phase and a measurement phase, wherein the receiver measures a received power during the measurement phase and
15 transmits information on the measured power to the transmitter, wherein the transmitter compares the power transmitted therefrom to the power measured by the receiver and identifies a power loss therefrom, wherein the power phase does not occur if the power loss exceeds a maximum allowable threshold.

20 Methods for wireless transmission of a power are known in prior art. These methods serve for recharging electronic devices such as cordless telephones for example. For this purpose, the object to be charged is placed on a charging pad, wherein the transmitter (charging pad) and the receiver (device to be charged) permanently exchange data in order to guarantee optimum power transmission. During this
25 process, the receiver requests at regular intervals changes in the power level from the transmitter. To guarantee interoperability between charging devices and receivers from different manufacturers, a so-called "Wireless Power Standard" (WPC) has been established in prior art, wherein certain technical data such as the transmitted power for instance have been standardized. The so-called "Low Power
30 Standard" (LP) represents such a standard. This standard transmits 5 W between transmitter and receiver in a wireless manner.

For effecting the transmission between the transmitter and the receiver only if a "valid" receiver is in fact present in the charging zone of the transmitter, prior art also
35 provides for a so-called foreign object detection which is used for verifying that the

transmitter is in fact connected with a "valid" receiver and that a metal foreign object such as a coin for instance which may be present in the charging zone by accident, is in fact not present in the transmission zone in addition to the valid receiver. Metallic foreign objects absorb electromagnetic radiation transmitted from the transmitter to the receiver. This foreign object detection thus prevents a foreign object from being heated to a high temperature by absorbed power.

The foreign object detection works in such a way that the receiver measures how much power it receives from the transmitter and sends this measured value as information to the transmitter. The transmitter in turn compares the information sent to it to the power output therefrom. In case the power loss (transmitted power minus received power) exceeds a predetermined value, it is assumed that a foreign object is present in the transmission zone of the transmitter and receives more power than allowed. In this case, the power transmission is interrupted. The threshold value predetermined for the power loss is dependent on the measuring accuracy of the measuring system that is employed and on the respective standard at which the power is transmitted from the transmitter to the receiver. In the Low Power Standard, a power of 5 W is output. At a regular measuring accuracy of approx 5%, it is possible to measure the power loss with an accuracy down to 250 mW. This power loss of 250 mW leads to a foreign object being heated to 80° for example. Such heating would still be acceptable under the aspects of safety.

However, if a higher level of power is to be transmitted between the transmitter and the receiver, considerably higher temperatures are caused with respect to a possible foreign object, with a measuring accuracy of 5%. At the transmission of a power in the so-called Medium Power Standard, which transmits an output power of 15 W, accurate measurement of the power loss is possible down to 750 mW, which however would lead to excessive heating of a foreign object.

Based on the above-described problem, it is an **object** of the present invention to provide a method for wireless transmission of an output power between a transmitter and a receiver which enables foreign object detection in an accurately measured manner, in particular in a manner independent of the use of a particular power standard, and thus prevents excessive and hazardous heating of foreign objects.

For the **solution** of the above-described object, the invention proposes a method for wireless transmission of an output power between a transmitter and a receiver, comprising a power phase and a measurement phase, wherein the transmitter
5 transmits a power during the measurement phase which is smaller than the power transmitted during the power phase. According to the invention, the foreign object detection is thus effected at a power level which is lower compared to that of the power phase and which is sized in such a manner that the power loss does not lead to excessive heating of a possible foreign object. Accordingly, for performing the
10 measurement phase, the power transmitted from the transmitter is reduced to an amount that guarantees safety also in case of the presence of a metallic foreign object.

It can be provided that the measurement phases and the power phases alternate in a
15 temporal succession. The measurement phase is repeated at a particular time interval between successive power phases in order to thus guarantee a high degree of safety at regular intervals.

Alternatively, it can also be provided that a one-time measurement phase is
20 performed in a temporal succession prior to a power phase. The measurement phase serves as an initial process ahead of a long continuous power phase. This variant of the embodiment is based on the assumption that it is relatively unlikely under certain structural conditions of the transmitter and the receiver that a foreign object comes between the transmitter and the receiver during the recharging process and may thus
25 be heated. Applied to the transmission of an output power of 15 W (Medium Power Standard), the power loss can be measured for example within a 5 W measurement phase (Low Power Standard) and the calculated power loss can be memorized so that the same serves as a calibration for guaranteeing the measuring accuracy also at 15 W. Such switching from a 15 W power phase to a 5 W measurement phase and
30 vice versa is possible because both standards are compatible with each other and especially have a same transmission frequency. In case no foreign object is detected during the measurement phase, i.e. the power loss is below the maximum allowable threshold, the power phase is switched.

It is provided in particular that the transmitter outputs a power of more than 5 W, particularly 15 W, during the power phase. With such a configuration, it is possible to benefit from the invention in a particularly advantageous way. Power phases with an output power of more than 5 W, particularly 15 W, are unsuitable for taking a safe measurement of the power loss. If the measurement was taken at the output power of the power phase (e.g. 15 W), the resulting power loss would be 250 mW at a measuring accuracy of 5% and the resulting foreign object temperatures would accordingly be higher than 80°C for example. This can lead to dangerous burns or even to fire. Insofar the invention is useful and advantageous wherever more than 5 W are transmitted during the power phase.

It is particularly advisable that the transmitter transmits a power of 5 W at maximum during the measurement phase. But also a power clearly lower than 5 W can be transmitted. Thus the power transmitted during the measurement phase is preferably lower than the power of more than 5 W, particularly 15 W in the Medium Power Standard, transmitted during the power phase. Accordingly, this configuration advantageously results in a power phase with high power and in a measurement phase with low power so that a high power can be transmitted during the power phase on the one hand and on the other hand the foreign object detection can be performed without the risk of fire or injury during the measurement phase.

According to a first embodiment of the invention, the transmitter initiates a measurement phase. In this case, the transmitter transmits on its own initiative an output power of 5 W for instance. The repetition frequency of the measurements during the measurement phases advantageously corresponds to the repetition frequency of the measurements during the power phase known in prior art. In the present Medium Power Standard, the repetition frequency of the foreign object measurement typically is 1.5 s and 4 s at maximum. This means that the time difference between two successive measurements amounts to 1.5 s and to 4 s at maximum. In this manner, there is simultaneously defined the time interval within which the receiver needs to report the information on the received power to the transmitter. Accordingly, the period between two reports shall typically be 1.5 s, but can also be 4 s at maximum. The receiver recognizes the measurement phase by the reduction of the power to 5 W and thereupon measures the power received during

this measurement phase and transmits information on that back to the transmitter. After the receiver has received the information, it increases the transmitted power to the power of the power phase, i.e. to more than 5 W, particularly 15 W, if the measured power loss between the transmitted power and the received power does not exceed a predetermined threshold. For this transmitter-initiated change of the power level there is merely required a receiver of a simple structure.

Alternatively, it can be provided that the receiver initiates a measurement phase. In this variant of the embodiment, the receiver prompts the transmitter to reduce the transmitted power, for example to 5 W. In this case, too the repetition frequency of the measurements during the measurement phase advantageously corresponds to the repetition frequency of the measurements during the power phases known in prior art, wherein the repetition frequency changes more or less, because according to this variant the receiver may determine when it takes the measurement as long as it remains within the maximum allowable time period between two measurements (4 s). Advantageously, this "request" of the receiver is made using a particular data format "foreign object detection", which can accelerate the process compared to a common misperformance data packet. After power reduction, the receiver measures the power received within the measurement phase and reports this information to the transmitter. The transmitter receives this information and compares the power transmitted therefrom to the power received by the receiver. Depending on the power loss that is determined in this way, the power transmission is either continued or not, i.e. in case the power loss is below the predetermined threshold, the receiver can again request an output power which is higher than the measurement power. It is advantageous that the receiver itself can spontaneously determine the point of time best suited for initiating the measurement phase. It is possible in particular that the receiver chooses a point of time for the initiation at which small differences in power exist for both the transmitter and the receiver itself between the power phase and the measurement phase. The receiver may particularly choose the best point of time in dependence of the present charging current. Moreover, as the power transmitted from the transmitter is requested by the receiver, it is possible for the receiver to initiate a gradual reduction of the transmitted power so that between the power of the power phase and the power of the measurement phase there is not a gradual change in the power but rather a continuous loss of power. Thus the occurrence of

electromagnetic interfering fields within the integrated circuits of both the receiver and the transmitter is prevented.

In the following the invention will be described in more detail by way of examples.

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It is shown by:

Fig. 1

- 10 a) a transmitter with a receiver placed thereon,
 b) a transmitter with a foreign object placed thereon,
 c) a transmitter with a receiver and a foreign object placed thereon;

15 Fig. 2 power characteristics of the transmitter and receiver during a transmitter-initiated process;

Fig. 3 power characteristics of the transmitter and receiver during a receiver-initiated process.

20 Fig. 1a) to c) illustrate the different situations the transmitter 1 can be in.

According to a), a receiver 2, for example a cordless telephone, is in communication with the transmitter 1. Prior to transmitting power, the receiver 2 identifies itself to the transmitter 1. In this phase, the transmitter 1 preferably is in the measurement phase
 25 5 so that it outputs only a low power. For the purpose of measurement, the transmitter 1 receives from receiver 2 a response signal including information on the power the receiver 2 has received from the transmitter 1. Now the transmitter calculates a power loss as difference from the power transmitted therefrom and the power transmitted back from the receiver 2. In case the amount of this power loss is
 30 below a maximum threshold, the transmitter 1 identifies the receiver 2 as a "valid object" and switches from the measurement phase 5 (e.g. 5 W) to the power phase (e.g. 15 W). Thereafter the receiver 2 is charged with 15 W power.

According to b), there is only a foreign object 3 placed on the transmitter 1. This foreign object 3 can be a coin for example. On the basis of changes in the electromagnetic field, the transmitter 1 recognizes that a field-absorbing object 3 is placed on the transmitter. As a consequence, the transmitter 1 increases the output power for a short time, with the aid of which the receiver 1 typically identifies itself to the transmitter 1 via feedback. As the foreign object 3 does, however, not possess such feedback capabilities, the transmitter 1 again cuts off the output power as a result of the lacking feedback.

In c), a situation is shown in which both a receiver 2 and a foreign object 3 are in contact with the transmitter 1. In this situation, the transmitter 1 receives from the receiver 2 information on the power which the receiver 2 receives from the transmitter 1. Due to the foreign object 3, which is additionally placed on the transmitter 1, the receiver 2 receives a lower power from the transmitter 1 than this would be the case without a foreign object 3. The transmitter 1 then compares the power transmitted therefrom to the power received by the receiver 2 and calculates the difference, i.e. the power loss. In case this power loss exceeds a predetermined threshold, the power phase is not initiated, i.e. the transmitter 1 remains in the measurement phase 5 until the foreign object 3 is removed. As the power loss can be determined only with an accuracy that is dependent on the measuring method, a "dark zone" is produced in which the presence of the foreign object 3 cannot be detected and the latter is therefore heated. Accordingly, the threshold for the power loss is predetermined by the measuring accuracy of the measuring system.

Fig. 2 shows an example in which switching between the power phase 4 and the measurement phase 6 is initiated by the transmitter 1. The example is directed to a variant of the embodiment in which the method according to the invention is carried out with the power phases 4 and the measurement phases 5 alternating. Based on a power phase 4, in which the transmitter 1 transmits 15 W power, the transmitter 1 switches the transmitted power from 15 W to 5 W after a predetermined time period. The transmission of a power of 5 W here corresponds to the measurement phase. As can be seen in the Figure, this results in a gradual decrease from 15 W to 5 W. The output power respectively stated corresponds to the power of the Medium Power Standard and the Low Power Standard, although the invention can be implemented

also with other power values. In the WPC MP Standard (Medium Power Standard), the period between the individual transmissions typically corresponds to 1.5 s and to 4 s at maximum. During the measurement phase 5, the receiver 2 measures the power received from the transmitter 1 and correspondingly informs the transmitter 1 on the power it has received. In the present example, the received power amounts to 4 W. Then the transmitter 1 calculates the difference between the power (5W) transmitted therefrom and the power (4 W) received by the receiver 2. In case the difference (0.2 W), i.e. the power loss, is below a predetermined threshold, it will be inferred that no foreign object 3 is present on the transmitter (this is assumed in the present case). Then the transmitter 1 again switches the power transmitted therefrom from 5 W to 15 W. With this action, a next power phase 4 begins. The switching between the power phase 4 and the measurement phase 5 can take place at predetermined interval. But alternatively it would also be possible for this switching to take place at irregular intervals, for example based on an instruction transmitted from the receiver 2, wherein the instruction is transmitted at moment which is deemed suitable by the receiver 2.

Fig. 3 shows a method in which the change in power level is initiated by the receiver 2. At a point of time that can be freely determined by the transmitter 1, the transmitter 1 is prompted by the receiver 2 to reduce the transmitted power so that a measurement phase 5 can be performed with lower output power. As shown in Fig. 1, the receiver 2 can gradually request the transmitter 1 to continuously reduce the transmitted power until the power has decreased from 15 W to 5 W. The receiver 2 can determine the best point of time for switching the transmitted power in accordance with its present charging and load current situation. In case the receiver 2 only receives 13 W out of 15 W, as in the given example, the same can prompt an immediate measurement phase 5 in which it is verified if a foreign object 3 is present between the transmitter 1 and the receiver 2. During the measurement phase 5, the receiver 2 measures the power received from the transmitter 1 and informs the transmitter 1 about its measuring result. After the transmitter 1 has received this information from the receiver 2, it calculates the power loss and prevents switching to the power phase 4 until the foreign object 3 is removed if the presence of a foreign object is assumed. On the other hand, if the power loss is below the respective predetermined threshold, the transmitter 1 switches the power from the measurement

power, e.g. 5 W, back to the power for the power phase 4, e.g. 15 W, on request from the receiver 2.

List of reference numbers

5	
1	transmitter
2	receiver
3	foreign object
4	power phase
10	5 measurement phase

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- 10 1. Method for wireless transmission of a power between a transmitter (1) and a receiver (2), comprising a power phase (4) and a measurement phase (5), wherein the receiver (2) measures a received power during the measurement phase (5) and transmits information on the measured power to the transmitter (1), wherein the transmitter (1) compares the power transmitted therefrom to the power measured by the receiver (2) and identifies a power loss therefrom,
- 15 wherein the power phase (4) does not occur if the power loss exceeds a maximum allowable threshold,
characterized in that the transmitter (1) outputs a power during the measurement phase (5) which is lower than the power output during the power phase (4), wherein the power during the measurement phase (5) is chosen
- 20 such that the power loss is accurately measured down to 250 mW.
2. Method according to claim 1, characterized in that the measurement phases (5) and power phases (4) alternate in a succession of time.
- 25 3. Method according to claim 1 or 2, characterized in that the measurement phases (5) are performed at regular time intervals.
4. Method according to claim 1, characterized in that prior to a power-phase (4), a one-time measurement phase (5) is performed.
- 30 5. Method according to any one of the preceding claims, characterized in that during a power phase (4), the transmitter (1) outputs a power of more than 5 W, particularly 15 W.

6. Method according to any one of the preceding claims, characterized in that during a measurement phase (5), the transmitter (1) outputs a power of 5 W at maximum.
- 5 7. Method according to any one of the preceding claims, characterized in that the transmitter (1) initiates a measurement phase (5).
8. Method according to any one of the preceding claims, characterized in that the receiver (2) initiates a measurement phase (5).