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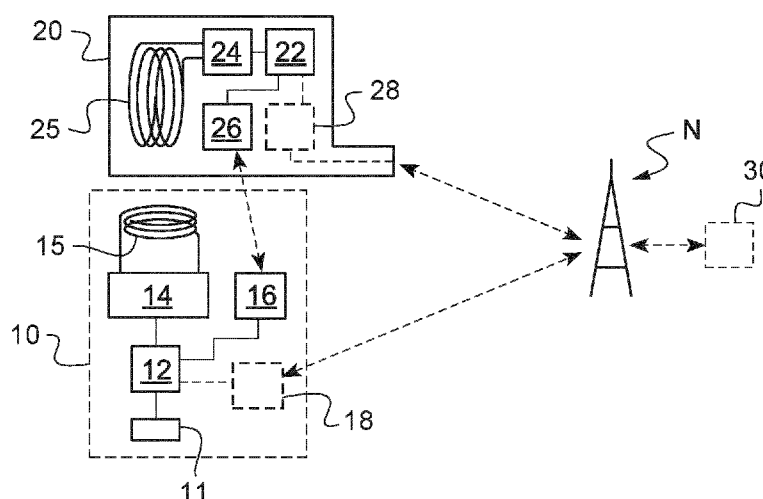
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(54) Title: METHOD FOR WIRELESSLY CHARGING AN ELECTRONIC APPARATUS AND CHARGING DEVICE

Fig.1



(57) Abstract: A method is described for wirelessly charging an electronic apparatus (20) using a charging device (10) comprising a charging antenna (15), a processor (12) and a memory (11) storing a resident executable firmware. This method includes the following steps: - transferring a string of data relative to a specific charging power profile from the electronic apparatus (20) to the charging device (10); - storing said string of data in the memory (11) of the charging device (10); - charging the electronic apparatus (20) through a charging process by executing instructions of the resident executable firmware and by using at least part of the stored string of data. A corresponding charging device (10) is also described.



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METHOD FOR WIRELESSLY CHARGING AN ELECTRONIC APPARATUS AND CHARGING DEVICE

TECHNICAL FIELD OF THE INVENTION

5 The invention relates to wireless charging of electronic apparatuses.

More precisely the invention relates to a method for wirelessly charging an electronic apparatus and to a corresponding charging device.

BACKGROUND INFORMATION AND PRIOR ART

10 It has been proposed to wirelessly charge an electronic apparatus (*e.g.* a smartphone) using a charging device comprising a charging antenna.

Some electronic apparatuses require the charging process to be performed according to a specific charging profile (also termed "*power profile*"), in particular when it comes to charging with an increased charging power (such as *e.g.* above 5 W).

15 Thus, when charging a given apparatus using a charging device that is not specifically designed to perform a charging process according to the charging profile specific to this given apparatus, the wireless charging may proceed using a standard power profile at a lower power than the one expected by the user, resulting in extended charging times.

20 SUMMARY OF THE INVENTION

In this context, the invention provides a method for wirelessly charging an electronic apparatus using a charging device comprising a charging antenna, a processor and a memory storing a resident executable firmware, said method comprising the following steps:

- 25
- transferring a string of data relative to a specific charging power profile from the electronic apparatus to the charging device;
 - storing said string of data in the memory of the charging device;
 - charging the electronic apparatus through a charging process by executing instructions of the resident executable firmware and by using at least
- 30 part of the stored string of data.

Data of the string of data transferred from the electronic apparatus to the charging device enable the charging device to adapt itself to the charging profile specific to the electronic apparatus. The charging device can thus charge the electronic apparatus in optimal conditions.

According to possible optional features:

- the stored string of data includes a cryptographic key;

- said charging process includes a method for authentication of the charging device by the electronic apparatus using said cryptographic key;

5 - said method for authentication includes a mutual authentication of the charging device and the electronic apparatus;

- the stored string of data includes at least one parameter for configuring the charging device;

- said parameter is a charging frequency;

10 - said charging process includes generating an alternating magnetic field at said charging frequency;

- a part of the transferred string of data is a piece of firmware suitable for execution by the processor so as to control the charging process according to the specific charging power profile;

15 - the memory stores a table containing a plurality of power profile data respectively associated with a plurality of electronic apparatus or electronic apparatus types;

- the stored string of data is stored in said table;

20 - said string of data is transferred from the electronic apparatus to the charging device via a wireless communication;

- said wireless communication is a near-field communication;

- said wireless communication is a communication via a wireless charging protocol associated to the wireless charging process;

- said wireless communication is a Bluetooth communication;

25 - said wireless communication is in the ultra wide band (UWB) range;

- said string of data is transferred from the electronic apparatus to the charging device via a remote computer;

- the electronic apparatus is a smartphone.

30 The invention also provides a charging device comprising a charging antenna, a processor and a memory storing a resident executable firmware, said processor being programmed to:

- receive a string of data related to a specific charging power profile from the electronic apparatus;

- store said string of data in the memory of the charging device;

- control a charging process by executing instructions of the resident executable firmware and by using at least part of the stored string of data.

Other features and advantages of the embodiments of the present invention will be better understood upon reading of preferred embodiments thereof
5 with reference to the appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows an exemplary context in which the invention may be implemented;

Figure 2 shows the main steps of a method for wirelessly charging an
10 electronic apparatus using a charging device according to a possible embodiment of the invention;

Figure 3 represents steps of a first exemplary charging process;

Figure 4 represents steps of a second exemplary charging process;

Figure 5 represents steps of a third exemplary charging process.

15 DETAILED DESCRIPTION OF EXAMPLE(S)

Figure 1 shows a possible context in which the invention may be used. The invention is however not limited to this possible context.

In this context, a charging device 10 (also termed base station) is configured to wirelessly charge an electronic apparatus 20, such as a smartphone.

20 The charging device 10 comprises a charging antenna 15 (e.g. an inductive antenna), a driver 14, a processor 12, a memory 11 and a communication circuit 16.

In practice, the processor 12 and the memory 11 may be grouped in a single electronic circuit (such as a microcontroller). In other embodiments
25 however, the processor 12 and the memory 11 could be formed by separate electronic circuits (such as separate integrated circuits).

The memory 11 stores a resident executable firmware. The resident executable firmware includes software instructions which are suitable to control the charging device 10 to perform at least part of a wireless charging process (as
30 further described below, referring in particular to Figure 2), when these software instructions are executed by the processor 12.

The driver 14 is configured to inject an alternating current into the charging antenna 15 (under control of the processor 12) such that the charging antenna 15 generates an alternating magnetic field for charging the electronic

apparatus 20, as further explained below.

The communication circuit 16 is suitable for establishing a wireless data communication with another electronic device, such as the electronic apparatus 20 as described below. The wireless data communication may in practice be a Bluetooth communication, for instance. According to another embodiment, the wireless data communication may be in the ultra wide band (UWB) range. According to yet another embodiment, the wireless data communication may be a near field communication, for instance in accordance with a NFC protocol.

As further described below, according to a possible variation, communication between the charging device 10 and the electronic apparatus 20 may be performed via the charging antenna 15, using a wireless charging protocol associated with the wireless charging process.

The charging device 10 may also comprise (or be externally connected to) a cellular network module 18 for exchanging data over a cellular network N with other devices, such as the electronic apparatus 20, as further explained below.

The electronic apparatus 20 comprises a processor 22, a charging circuit 24, a charging antenna 25 and a communication circuit 26.

The charging circuit 24 is suitable for charging a battery (not shown) of the electronic apparatus 20 when the charging antenna 25 is subjected to a varying magnetic field, such as the alternating magnetic field produced by the charging antenna 15 of the charging device 10.

The communication circuit 26 is suitable for establishing a wireless data communication with other electronic devices. In particular, the communication circuit 26 of the electronic apparatus 20 is suitable for establishing a wireless data communication with the communication circuit 16 of the charging device 10, such that the processor 12 of the charging device 10 and the processor 22 of the electronic apparatus 20 may exchange data over this wireless data communication, in particular as proposed below

As noted above, exchange of data between the processor 12 of the charging device 10 and the processor 22 of the electronic apparatus 20 may in a possible variation be performed via the charging antenna 15 and the charging antenna 25, using a wireless charging protocol associated to the wireless charging process.

The electronic apparatus 20 may also comprise (or, as a possible

variation, be externally connected to) a cellular network module 28 for exchanging data over a cellular network N with other devices, such as the charging device 10.

Thus, according to a possible variation, data exchanged between the processor 12 of the charging device 10 and the processor 22 of the electronic apparatus 20 may be transferred via the cellular network N.

Figure 2 shows the main steps of a possible method for wirelessly charging the electronic apparatus 20 using a charging device 10.

This method starts with a step S2 of establishing a communication (*e.g.* a wireless communication as explained below) between the charging device 10 and the electronic apparatus 20, in order in particular to enable an exchange of data between the processor 12 of the charging device 10 and the processor 22 of the electronic apparatus 20.

As explained above, the communication established in step S2 is for instance a wireless data communication established between the communication circuit 16 of the charging device 10 and the communication circuit 26 of the electronic apparatus 20.

According to a possible variation, the communication established in step S2 may be a wireless communication established via the charging antenna 15 of the charging device and the charging antenna 25 of the electronic apparatus, using a wireless charging protocol associated with the wireless charging process.

According to another possible variation, the communication established in step S2 is established over the cellular network N (and possibly over at least another network connected to the cellular network N) using the cellular network module 18 of the charging device 10 and the cellular network module 28 of the electronic apparatus 20. In this case, communication is generally made through at least one remote computer 30.

When the communication between the charging device 10 and the electronic apparatus 20 is established as just mentioned, the electronic apparatus 20 (under control of its processor 22) sends an identifier ID of the electronic apparatus 20 to the charging device 10 using the established communication (step S4). In a possible embodiment, the charging device 10 could also send its own identifier to the electronic apparatus 20 for mutual identification.

The charging device 10 (precisely: the processor 12 of the charging device 10) receives the identifier ID of the electronic apparatus 20 in step S6.

In step S8, the processor 12 of the charging device 10 may then determine based on the identifier ID whether the current configuration of the charging device 10 is suitable for charging the electronic apparatus 20 using a charging process in accordance with a power profile associated with the electronic
5 apparatus 20.

This determination is for instance performed by:

- determining a type of the electronic apparatus 20 (here: a type of smartphone) based on a relevant part of the identifier ID; and
- determining whether the charging process in accordance with the power
10 profile associated with this type of electronic apparatus 20 may be performed thanks to the resident executable firmware and data relative to this power profile currently stored in the memory 11 as further explained below.

This last sub-step may for instance be performed by determining whether data relative to the power profile associated with the type of the electronic
15 apparatus 20 have been previously stored in the memory 11.

According to a possible variation, the determination of step S8 is performed by determining whether the electronic apparatus 20 identified by the identifier ID has previously been charged by the charging device 10 using a charging process in accordance with a power profile associated with this electronic
20 apparatus, for instance by parsing a log of identifiers of electronic apparatuses previously charged by the charging device 10.

If the processor 12 of the charging device 10 determines in step S8 that the current configuration of the charging device 10 is suitable for charging the electronic apparatus 20 in accordance with the power profile associated with the
25 electronic apparatus 20, the method continues with step S24 further described below (or, in other embodiments, directly with step S26).

If the processor 12 of the charging device 10 determines in step S8 that the current configuration of the charging device 10 is not suitable for charging the electronic apparatus 20 in accordance with the power profile associated with the
30 electronic apparatus 20, the processor 12 of the charging device 10 sends in step S10 (using the communication established in step S2) a piece of information INFO indicating to the electronic apparatus 20 that its power profile is currently not supported by the charging device 10. The transmission of the piece of information INFO may for instance be performed during a negotiation phase during which the

charging device 10 and the electronic apparatus 20 exchange data defining their respective capabilities. The transmission of the piece of information by the charging device 10 may for instance be performed in response to a dedicated request sent by the electronic apparatus 20.

5 The electronic apparatus 20 (precisely its processor 22) receives the piece of information INFO at step S12. The electronic apparatus 20 is thus aware that additional data D should be sent to the charging device 10 (as explained below) if the charging process should be performed in accordance with the power profile specific to the electronic apparatus 20.

10 The processor 22 may then optionally request a confirmation from the user of the electronic apparatus 20 (step S14), for example by displaying a corresponding message on a user interface (not shown) of the electronic apparatus 20 and waiting for a specific user feedback on the same user interface.

 In case user confirmation is requested but no confirmation from the user
15 is detected by the electronic apparatus 20, data relative to the power profile are not transmitted to the charging device 10 and charging in accordance with this power profile cannot therefore be implemented. Charging using a standard power profile at a lower power may however be performed (in step S16), for instance.

 In case user confirmation is detected by the electronic apparatus (or in
20 embodiments where no user confirmation is needed), the processor 22 of the electronic apparatus 20 commands at step S18 transferring, from the electronic apparatus 20 to the charging device 10 and using the communication established in step S2, a string of data D relative to the charging power profile associated with the electronic apparatus 20.

25 As further described below, the string of data D may include for instance a cryptographic key and/or one or several parameter(s) for configuring the charging device (such as a charging frequency used during the charging process) and/or a piece of firmware suitable for execution by the processor so as to control the charging process according to the charging power profile associated with the
30 electronic apparatus 20.

 The charging device 10 (precisely: the processor 12 of the charging device 10) receives the string of data D at step S20.

 The processor 12 of the charging device may thus store the string of data D in the memory 11 of the charging device 10 (step 22).

The string of data D is for instance stored in association with data representing the type of the electronic apparatus 20 (determined based on the identifier ID), possibly in a table containing a plurality of power profile data respectively associated with a plurality of electronic apparatus types.

5 The method then proceeds to step S26 described below, wherein the stored string of data D is used.

 When the determination step S8 branches to step S24 as indicated above, the processor 12 reads in this step S24 the string of data D relative to the power profile in the table just mentioned. For instance, the processor 12
10 determines data representing the type of electronic apparatus 20 based on the identifier ID and reads the string of data D stored in the table in association with these data representing the type. (The string of data D may have been stored in the table for instance during a previous execution of the method, during which step S22 was implemented as explained above).

15 The charging device 10 may then proceed to a step S26 of charging the electronic apparatus 20 through a charging process.

 Part at least of this charging process is performed as a result of the processor 12 executing instructions of the resident executable firmware and using at least part of the string of data D.

20 It may be noted in this respect that at least some of the steps performed by the processor 12 of the charging device 10 as mentioned above (*i.e.* any of steps S2, S6, S8, S10, S20, S22, S24) may also be performed in practice thanks to execution of software instructions of the resident executable firmware by the processor 12.

25 Figure 3 shows a first possible implementation of the charging process of step 26.

 As described below, in this first possible implementation, the string of data D is a cryptographic key and mutual authentication between the charging device 10 and the electronic apparatus 20 is required prior to effectively
30 proceeding to charging of the electronic apparatus 20 by the charging device 10 at nominal power.

 At least some of the exchanges of data described below between the charging device 10 and the electronic apparatus 20 may be implemented via the communication established in step S2.

In step S50, the processor 22 of the electronic apparatus 20 sends a challenge CH (e.g. a random number) to the processor 12 of the charging device 10.

5 The processor 12 of the charging device 10 receives the challenge CH at step S52 and computes a response RSP at step S54, for instance by applying to the challenge CH a cryptographic algorithm using the cryptographic key included in the string of data D.

10 The processor 12 of the charging device 10 sends the response RSP and another challenge CH' to the processor 22 of the electronic apparatus 20 (step S56). This other challenge CH' is for instance a random number drawn by the processor 12 of the charging device 10 before step S56.

The processor 22 of the electronic apparatus 20 receives the response RSP and the other challenge CH' at step S58.

15 The processor 22 of the electronic apparatus 20 may thus possibly authenticate the charging device 10 in step S60 based on the response RSP and the challenge CH (sent at step S50). This is for instance implemented in practice by applying to the challenge CH the same cryptographic algorithm as in step S54 above, using the cryptographic key, and comparing the result provided by this new implementation of the cryptographic algorithm with the challenge response RSP
20 received at step S58 (the charging device 10 being authenticated in case of equality).

If the charging device 10 is not authenticated in step S60, charging at nominal power cannot be performed. Charging using a standard power profile at a lower power may however be performed (in step S62), for instance.

25 If the charging device 10 is authenticated in step S60, charging at nominal power may be performed in step S70 as described below. In some embodiments, step S70 would immediately follow step S60 if the charging device 10 is authenticated by the electronic apparatus 20.

30 In the present embodiment however, in case of authentication of the charging device 10 by the electronic apparatus 20 in step S60, the processor 22 of the electronic apparatus 20 also computes in step S63a response RSP' based on the other challenge CH' and using for instance a secret key stored in the electronic apparatus 20. For instance, the response RSP' is obtained by applying to the other challenge CH' a cryptographic algorithm using this secret key.

The processor 22 of the electronic apparatus 20 then sends the response RSP' to the processor 12 of charging device 10 (step S64).

The processor 12 of the charging device 10 receives the response RSP' at step S65 and may thus possibly authenticate the electronic apparatus 20 based on the response RSP' (step S66).

Authentication is for instance determined by applying to the received response RSP' a cryptographic algorithm using the public key associated with the secret key of the electronic apparatus 20, and by comparing the result of this cryptographic algorithm to the challenge CH' sent in step S56 (the electronic apparatus 20 being authenticated in case of equality).

If the electronic apparatus 20 is not authenticated in step S66, charging at nominal power cannot be performed. Charging using a standard power profile at a lower power may however be performed (in step S62), for instance.

If the electronic apparatus 20 is authenticated in step S66, charging at nominal power is performed at step S70.

Figure 4 shows a second possible implementation of the charging process of step 26.

In this second possible implementation, the string of data D is a configuration parameter of the charging device 10, here a charging frequency used in the charging process.

In step S80, the processor 12 of the charging device 10 sends a command to the driver 14, which command specifies the charging frequency included in the string of data D.

Upon receiving this command, the driver 14 injects into the charging antenna 15 at step S82 a current having the frequency specified in the received command, i.e. corresponding to the charging frequency defined in the string of data D.

The charging device 10 thus produces a magnetic field alternating at the charging frequency corresponding to the power profile of the electronic apparatus 20 (as defined in the string of data D transmitted by the electronic apparatus 20 in step S18 as explained above).

Figure 4 shows a third possible implementation of the charging process of step 26.

In this third possible implementation, the string of data D includes a piece

of firmware which execution by the processor 12 of the charging device 10 results in the charging device 10 performing part of the charging process of step S26.

At step S100, the processor 12 of the charging device 10 launches (by execution of a particular instruction of the resident executable firmware) execution of the piece of firmware included in the string of data D.

Some at least of the subsequent steps (and in particular steps S102, S106 and S108 described below) are thus performed due to execution of this piece of firmware by the processor 12 of the charging device 10.

In particular, execution of the piece of firmware by the processor 12 of the charging device 10 enables to establish a secure channel between the charging device 10 and the electronic apparatus 20 (step S102).

This secure channel is for instance based on the communication established in step S2, but data exchanged are in addition enciphered by a ciphering scheme set up by cooperation of the processor 12 of the charging device 10 executing the piece of firmware and the processor 22 of the electronic apparatus 20 executing corresponding software instructions. It may be reminded in this respect that the piece of firmware was earlier transmitted from the electronic apparatus 20 among the string of data D, as described above (see step S18).

The processor 22 of the electronic apparatus 20 then sends a cryptographic key K to the processor 12 of the charging device 10 over the secure channel (step S104).

The processor 12 of the charging device 10 thus receives the cryptographic key K (step S106) and may store this cryptographic key K in the memory 11 of the charging device 10.

Charging of the electronic apparatus 20 by the charging device 10 may then be performed in step S110 using the cryptographic key K, for instance for authentication of the charging device 10 (by use of the cryptographic key K) by the electronic apparatus 20, possibly in accordance with the solution described above referring to Figure 3.

In some embodiments, this step S100 may be performed by the processor 12 of the charging device 10 executing instructions of the piece of firmware included in the string of data D. However, in other embodiments, this step S100 may be performed by the processor 12 of the charging device 10 executing instructions of the resident executable firmware.

CLAIMS

1. Method for wirelessly charging an electronic apparatus (20) using a charging device (10) comprising a charging antenna (15), a processor (12) and a memory (11) storing a resident executable firmware, said method comprising the following steps:

- transferring (S18) a string of data (D) relative to a specific charging power profile from the electronic apparatus (20) to the charging device (10);

- storing (S22) said string of data (D) in the memory (11) of the charging device (10);

- charging (S26) the electronic apparatus (20) through a charging process by executing instructions of the resident executable firmware and by using at least part of the stored string of data (D).

2. Method according to claim 1, wherein the stored string of data (D) includes a cryptographic key.

3. Method according to claim 2, wherein said charging process includes a method for authentication of the charging device (10) by the electronic apparatus (20) using said cryptographic key.

4. Method according to claim 3, wherein said method for authentication includes a mutual authentication of the charging device (10) and the electronic apparatus (20).

5. Method according to any of claims 1-4, wherein the stored string of data (D) includes at least one parameter for configuring the charging device.

6. Method according to claim 5, wherein said parameter is a charging frequency and wherein said charging process includes generating an alternating magnetic field at said charging frequency.

7. Method according to any of claims 1 to 6, wherein a part of the transferred string of data (D) is a piece of firmware suitable for execution by the

processor so as to control the charging process according to the specific charging power profile.

5 8. Method according to any of claims 1 to 7, wherein the memory (11) stores a table containing a plurality of power profile data respectively associated with a plurality of electronic apparatus types and wherein the stored string of data (D) is stored in said table.

10 9. Method according to any of claims 1-8, wherein said string of data (D) is transferred from the electronic apparatus (20) to the charging device (10) via a wireless communication.

15 10. Method according to claim 9, wherein said wireless communication is a near-field communication.

11. Method according to claim 9, wherein said wireless communication is a communication via a wireless charging protocol associated with the wireless charging process.

20 12. Method according to claim 9, wherein said wireless communication is a Bluetooth communication.

25 13. Method according to claim 9, wherein said wireless communication is in the ultra wide band (UWB) range.

14. Method according to any of claims 1-8, wherein said string of data (D) is transferred from the electronic apparatus (20) to the charging device (10) via a remote computer (30).

30 15. Method according to any of claims 1 to 14, wherein the electronic apparatus (20) is a smartphone.

16. Charging device (10) comprising a charging antenna (15), a processor (12) and a memory (11) storing a resident executable firmware, said

processor (12) being programmed to:

- receive a string of data (D) related to a specific charging power profile from the electronic apparatus (20);

- store said string of data (D) in the memory (11) of the charging device

5 (10);

- control a charging process by executing instructions of the resident executable firmware and by using at least part of the stored string of data (D).

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Fig.1

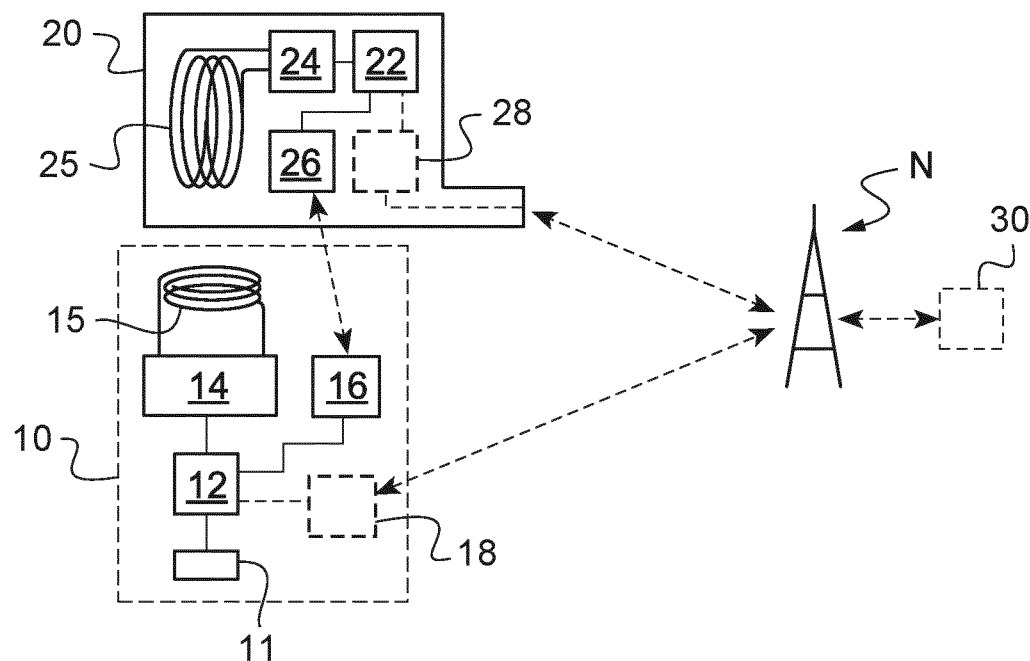
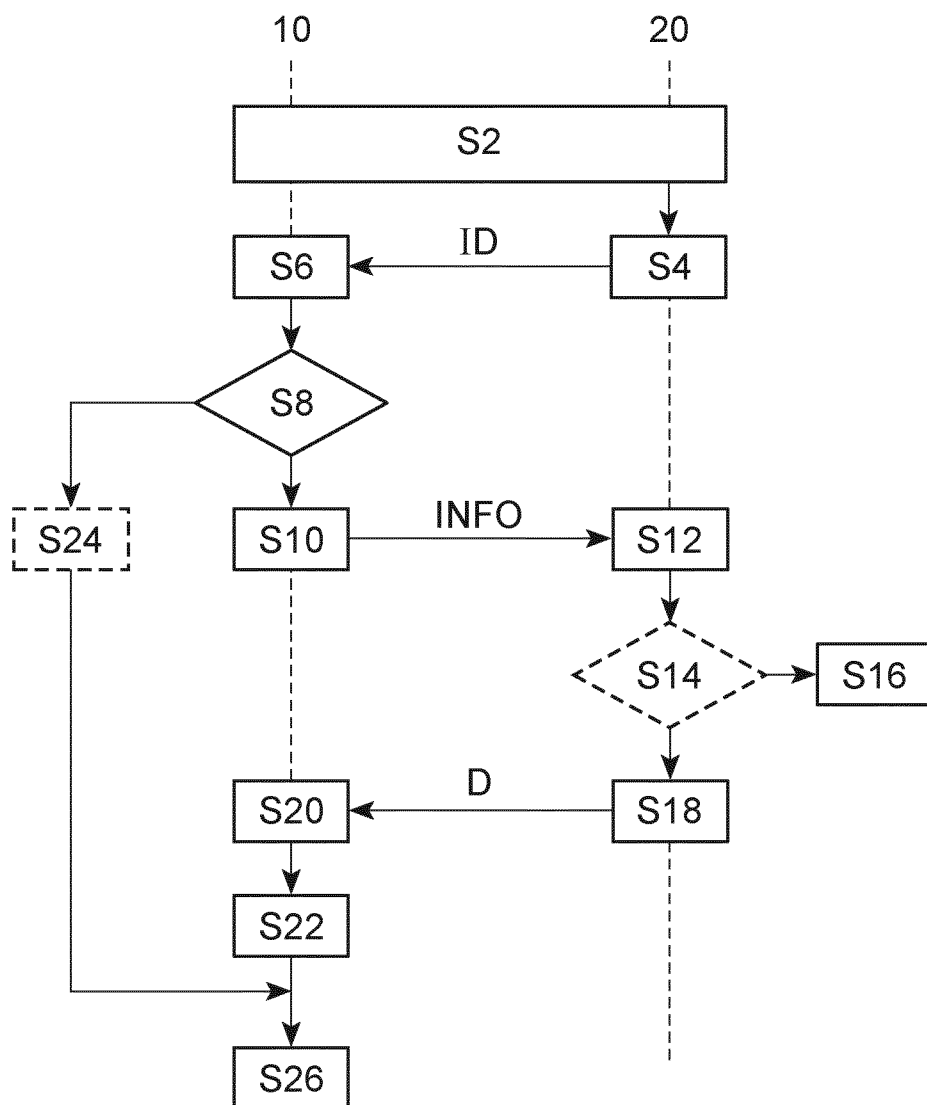


Fig.2



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Fig.3

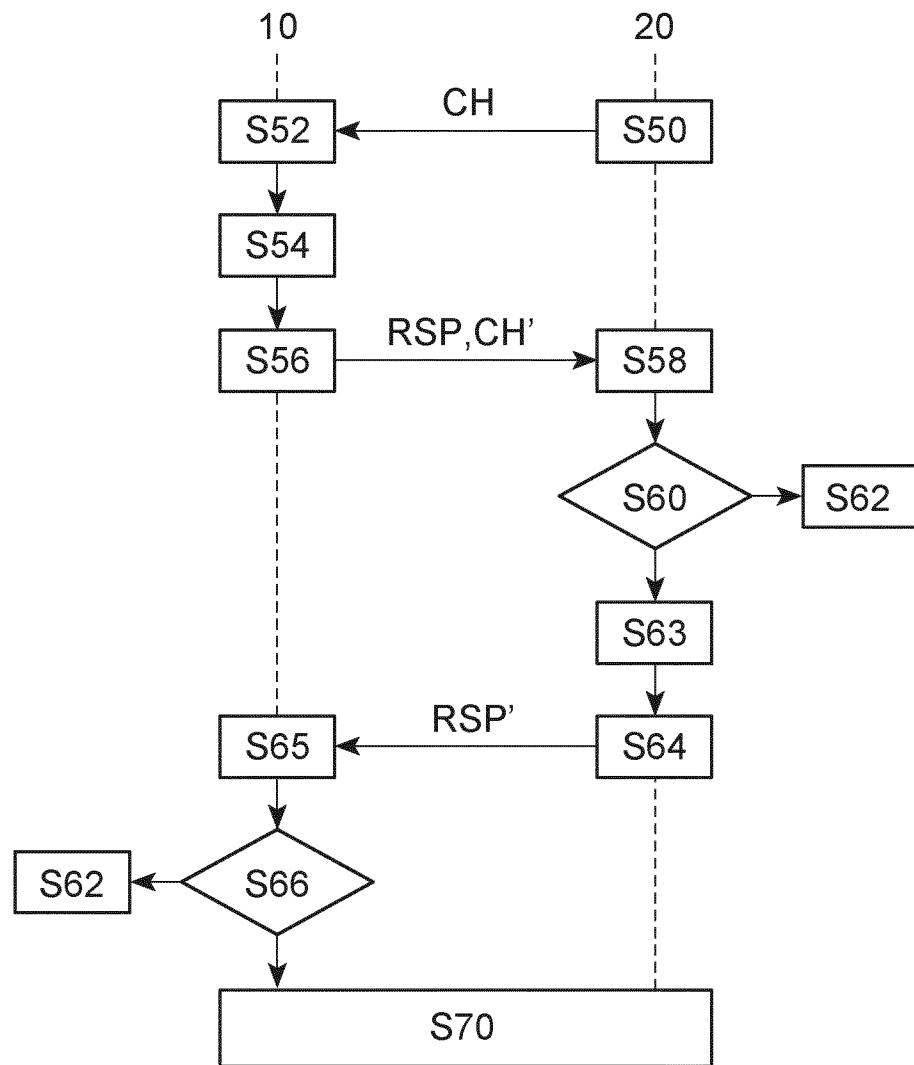
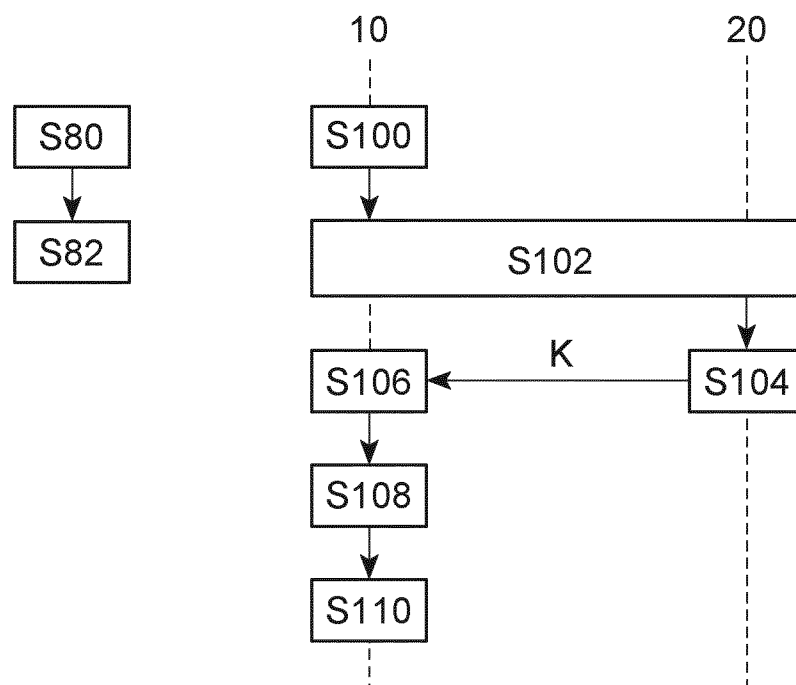


Fig.4



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/059897

A. CLASSIFICATION OF SUBJECT MATTER

INV. H02J50/10 H02J50/80
ADD. H04L9/32

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)

H02J H04L H04B B60L H01F

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 practicable, 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	WO 2017/171561 A1 (POWERBYPROXI LTD [NZ]) 5 October 2017 (2017-10-05)	1,2,5-7, 9-12, 14-16 3,4,13
Y	figure 1 page 2, lines 15-18 page 5, lines 3-11 page 7, lines 12-16 page 9, line 4 page 16, line 6 page 20, line 22 - page 23, line 5 page 23, lines 6-10 page 23, lines 19-21	
X	US 2011/018679 A1 (DAVIS ROY H [US] ET AL) 27 January 2011 (2011-01-27) paragraphs [0035], [0046], [0051], [0054], [0068], [0097], [0101], [0133]; figures 4,5 ----- -/-	1,5,8,9, 12,14-16



Further documents are listed in the continuation of Box C.



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Date of the actual completion of the international search

15 May 2020

Date of mailing of the international search report

27/05/2020

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/059897

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2017/205671 A1 (INTEGRATED DEVICE TECH [US]) 30 November 2017 (2017-11-30) paragraphs [0028], [0054] - [0072]; figures 4-5	3,4
Y	----- US 2013/029595 A1 (WIDMER HANSPETER [CH] ET AL) 31 January 2013 (2013-01-31) paragraphs [0062], [0078], [0117] -----	13

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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