(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
29 August 2013 (29.08.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/124841 Al

(51) International Patent Classification:
B60L 11/18 (2006.01) *H02J 3/32* (2006.01)
H02J3/14 (2006.01)

(21) International Application Number:
PCT/IL20 13/050 109

(22) International Filing Date:
6 February 2013 (06.02.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2182 13 20 February 2012 (20.02.2012) IL
61/603,489 27 February 2012 (27.02.2012) US

(71) Applicant: **BETTER PLACE GMBH** [CH/CH]; Industriestrasse 13C c/o Hodel Advokatur, + Notariat, CH-6304 Zug (CH).

(72) **Inventor; and**
(71) **Applicant** *(for VC only)*: **BETTER PLACE LABS ISRAEL LTD.** [IL/IL]; Afek industrial park 13 Ha'amal St., P.O.Box 11793, 48092 Rosh-Ha'aym (IL).

(72) **Inventors: GENZEL, Eran;** 30 Oren St., 44813 Oranit (IL). **SADOT, Emek;** POB 133, 19205 Moshav Ram On (IL). **STORFER, Lior;** 8 Alexander Pen St., 69641 Tel Aviv (IL).

(74) **Agent: REINHOLD COHN AND PARTNERS;** P.O.B. 13239, 6 113 1 Tel-Aviv (IL).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) **Title:** CHARGING MANAGEMENT METHOD AND SYSTEM

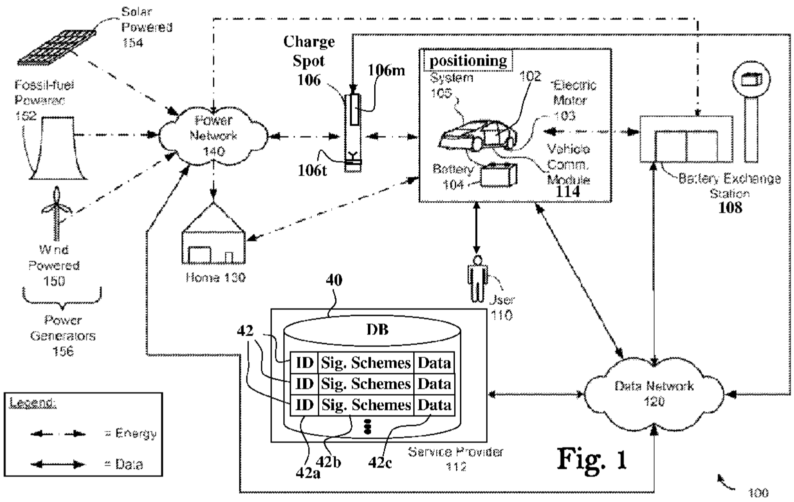


Fig. 1

(57) **Abstract:** Charging management techniques for electrically charging a chargeable device by electrically connecting and disconnecting electric charging power to the chargeable device and selectively performing at least one charging session by a plurality of timely separated charging cycles, depending on power management conditions or instructions.

WO 2013/124841 A1

CHARGING MANAGEMENT METHOD AND SYSTEM

TECHNOLOGICAL FIELD

The present invention generally relates to the management of electric charging of chargeable devices.

BACKGROUND

An increasing number of devices used in households and in industry are manufactured in the form of electrically chargeable devices (hereinafter also referred to as rechargeable or charging devices *e.g.* , for electric vehicles), for practical reasons (*e.g.* , obviating the need for power cords) and/or due to convenience of use. Electrical charging devices utilize rechargeable batteries, or another type of electrically renewable power source, as their main power source. One important use of rechargeable batteries is in the electric vehicle industry, which intends to gradually replace air polluting petrol and diesel internal combustion engine (ICE) vehicles with electric motor engine vehicles powered by rechargeable battery packs, or with so-called hybrid vehicles which utilize both internal combustion and electric motors.

Vehicles (*e.g.* , cars, trucks, planes, boats, motorcycles, autonomous vehicles, robots, forklift trucks, etc.), mainly used for transportation of passengers and goods, have become an integral part of the modern economy. Most vehicles used nowadays for transportation of passengers and goods are powered by internal combustion engines (ICE) which burn fossil fuels. Unfortunately, the use of fossil fuels, like gasoline, have numerous drawbacks, such as dependence on limited sources of fossil fuels (foreign sources of fossil fuels are often in volatile geographic locations), and pollution produced by their combustion, which contributes to global warming.

The vehicle industry is encouraged nowadays to shift to clean technologies employing electric motors powered by rechargeable fuel cells or batteries (generally referred to herein as rechargeable batteries), also known as electric vehicles. However, rechargeable batteries need to be recharged relatively often, and for this purpose charge spots (also referred to herein as charge poles or charger apparatus) that provide electrical current for recharging of the vehicles' batteries need to be widely spread and available to the users' of the vehicles in as many locations as possible. For example the vehicles may require that their batteries be recharged in parking lots of shopping centers or office buildings.

It is expected that as usage of electric vehicles increases electrical current demand from the charge spots sites will also increase, which may require substantial increase in the electricity supplying infrastructure, as well as increase in electrical power production capabilities, for addressing the increased demand for electrical charging currents.

US 2011/133693 to Lowenthal Richard *et al,* describes an electric vehicle charging station installed in users' residence, coupled with a main circuit breaker in an electrical service panel. The charging station described in this publication includes a current control device having a control pilot circuitry that modulates a pilot duty cycle to control the amount of electric current that can be drawn from the service drop power lines by the electric vehicle.

GENERAL DESCRIPTION

There is therefore a need for grid management solutions (also referred to herein as smart grid management) in electric power networks suitable to controllably manage the supply of electrical charging power to charging devices such as electric vehicles, as the demand for such electrical charging power increases. Accordingly, in some embodiments of the present invention there is provided a charge spot that is capable of controlling the electrical power that is being supplied to the batteries being charged, based on the capabilities of the electric power network (grid) and also based on the demand for electric charging power from a charging device associated with the battery.

Conventional charge spots and charging devices associated with batteries of electric vehicles typically utilize signaling schemes which mainly concern regulation of the amount of electric charging current drawn by the charging device. However, as the demand for supply of electrical charging power from the power network increases, it is desirable to enable the charge spot to controllably switch the electric charging power supply connected to charging devices of some vehicles between connected and disconnected states to properly manage charging of multiple vehicles by the power grid. A charge spot according to possible embodiments of the present invention, is thus further configured to switch the electric charging power supplied to batteries of charging devices between ON {*i.e.,* in which electrical charging power is supplied) and

OFF *(i.e.,* in which the electrical charging power supply is disconnected) states, to thereby provide control over the electrical charging power supplied by the electrical grid to the charging devices.

Preferably, the charge spot of the present invention is configured to notify the charging device its intent to switch the state of the electric charging power supply, and thereafter to switch the state of the electric charging power supply only after receiving a confirming indication from the charging device. In this way, a charge spot of the present invention is able to divide a charging session into a plurality of charging cycles. Each charging cycle may include charging cycle commencement and charging cycle termination notifications issued by the charge spot. Desirably, the charge spot connects the electrical charging power to the charging device only after receiving a charging cycle commencement confirmation from the charging device, and disconnects the electrical charging power from the charging device after receiving a charging cycle termination confirmation from the charging device.

Conventional charge spots utilize pilot signals, as defined in the standards used nowadays, to receive indications from the charging device connected thereto, and to regulate the electrical charging power drawn by the charging device. However, these pilot signaling schemes does not provide support for allowing the charge spot to indicate the charging device connected to its temporal termination or resumption of the electrical charging power supply.

Though the charge spot may forcibly terminate and resume the electrical charging power supply, applying this type of switching while the vehicle is actively drawing current from the grid is not desirable, and may have negative effects on the charge spot, such as a decrease in the mean time between failures (MTBF) component of the charge spot. Furthermore, the charging devices used in electrical vehicles to manage the charging of the battery are typically designed to consider sudden (unpredictable) removal of the electrical charging power as indicating the end of the charging session, and thus do not permit resumption of the charging session when the electrical charging power is reapplied.

There is therefore a need for a system and method for reliably managing a charging session allowing the charge spot to issue signals indicating that charging is to be temporarily disabled, and that the charging load needs to be removed prior to electrically disconnecting the charging supply power by the charge spot. For example, for electric vehicles, such charging session managing techniques may consider numerous charging signaling schemes employed in the recharging of vehicles' batteries, and use signaling schemes that do not contradict the standards used in the field of electric vehicle charging.

The inventors of the present invention found that a network comprising a plurality of communicatively coupled charge spots may be used to efficiently control the supply of electric charging power supplied by the charge spots. In possible embodiments, the charge spots include a communication interface configured and operable to communicate data with a central control system, and a conventional charging interface mechanically connectable to a charging device *(e.g.* , at least partially electric vehicle). For example, in possible embodiments the charge spots are compliant with the IEC61851 specification, which does not allow the termination and/or the recommencement of the electric charging supply power to be initiated by the charge spot, and therefore does not provide signaling schemes allowing the charge spot to indicate that it needs to terminate the electric charging supply, or to allow resuming the electric charging supply after such termination.

The inventors of the present invention have developed electric charging session management signaling schemes that can employ conventional communication carried out over a pilot signal line in compliance with standard specifications. In possible embodiments the electric charging session management signaling schemes are designed to allow the charge spot to divide a charging session into a plurality of charging cycles by signaling its intent to temporarily terminate a charging cycle, thereby allowing the charging device to remove its charging load prior to electrically disconnecting the charging supply power by the charge spot. For example, in possible embodiments the charge spot is adapted to indicate the end of a charging cycle upon receipt of data from the control system indicating that supply of the electrical charging power needs to be stopped.

In some embodiments the electric charging session management signaling schemes exploit pilot signals defined in the standard specifications to allow the charge spot to signal to the charging device that the draw of electrical charging power is to be temporarily stopped. For example, in possible embodiments the charge spot signals its intent to stop the supply of electrical charging power by driving a 5% duty cycle signal on the pilot signal line. According to standard specifications, such a signal indicates to the charging device to stop drawing electric charging power from the charge spot and wait for establishment of serial connection. This procedure allows the charging pole to force the charging device to remove the charging load *(i.e.,* to stop the consumption of the electric charging power) prior to electrical disconnection of the charging supply power by the charge spot.

In possible embodiments the electric charging session management signaling scheme is adapted to allow the charge spot to resume the charging session, once the charge spot is instructed by the control system to resume charging. Typically, resumption of the charging session is enabled upon receipt of data from the control system indicating a level of maximal permissible electric power that the charging device may consume if it needs to resume the charging session in order to further charge its battery.

For example, pulse width modulation (PWM), conventionally used in pilot signaling in standard charge spots to indicate a maximal charging power that the charging device is allowed to draw, may be used in the electric charging session management signaling scheme of the present application to allow the charge spot to indicate that the charging session may be resumed *(i.e.,* by commencing a new charging cycle). More particularly, the electric charging session management signaling scheme of the present application may be configured to allow the charge spot to set the duty cycle of the pilot signal to encode the maximal charging current that can be initially supplied by the electrical grid in the newly commenced charging cycle, by using the standard PWM duty cycle signal range between 8%-97%, as defined in the standard specification. A charging device that receives this pilot signal, analyses the received signal to determine its duty cycle, and based thereon starts a new charging cycle by drawing electrical charging current (i.e., reconnecting the charging load to the charge spot) at the permissible level of electrical charging power, as indicated by the duty cycle of the received pilot signal.

In some possible embodiments the electric charging session management signaling scheme is adapted to allow the charge spot to signal the charging device that it needs to electrically disconnect the supply of electrical charging power by providing fixed voltage signals (e.g., 12V) on the pilot signal line, prior to electrically disconnecting the charging supply power. The charging device may interpret such fixed voltage signal as 100% duty cycle, and responsively stop drawing any further electric charging power. The electric charging session management signaling scheme may be further adapted to allow the charge spot to provide an appropriate PWM pilot signal once charging is allowed to be resumed, and thereby indicate to the charging device that a new charging cycle can be started.

In some other possible embodiments the electric charging session management signaling scheme is adapted to allow the charge spot to drive a PWM pilot signal of 0% duty cycle (e.g., fixed -12V supply) to signal that it needs to electrically disconnect the electrical charging power supply (State F - indicating the charge spot is not available).

In yet some other possible embodiments the electric charging session management signaling scheme is adapted to allow the charge spot to indicate its intent to disconnect the electrical charging power by driving a 0 Volts signal on the pilot signal line.

In possible embodiments, the electric charging session management signaling scheme is adapted to resume the charging session once the charge spot is allowed to resume charging e.g., if so instructed by the control system, by changing the duty cycle of the PWM pilot signal to indicate the maximal electrical current that can be supplied from the electrical grid, e.g., using the duty cycle range of 8%-97%, as defined in the standard specification. Responsively, the charging device sensing the change in the duty cycle of the pilot signal, may resume the charging session according to the permissible charging level encoded in the received PWM pilot signal.

A charging session according to some embodiments may therefore include a plurality of charging cycles. In each of these charging cycles, supply of the electrical charging power may be commenced and terminated by the charge spot using signal indications defined by the electric charging session management signaling scheme of the application. The charging session termination/resumption signals, issued by the charge spot, are received by the charging device which is configured to terminate/resume charging processes (cycles) based on indications encoded in the received signals. The charging session in such embodiments may be terminated by mechanically disconnecting the electrical charging connectivity (*e.g.* , charging cable) which provides the mechanical and electrical connection between the charge spot and the charging device, preferably after the charging device stops drawing the electrical charging current and signals the same to the charge spot.

Therefore, the present invention, in some of its embodiments, allows a charging system to divide a charging session into a plurality of charging cycles. Optionally, the commencement and resumption of the charging cycles are determined based on data received by the charge spot *(e.g.* , from a control system), which may comprise grid control/management instructions. The charging spot may be configured to select at least one electrical charging session management signaling scheme suitable for indicating to the charging device the commencement and resumption of charging cycles while employing standard signaling conventionally employed in charge spots. By selecting a suitable charging session management signaling scheme, the charging session management techniques of the present application may be utilized to charge charging devices configured to conduct conventional charging sessions as defined in standard specifications. Therefore, conventional charging devices, such as electric vehicles complying with the industry's standard specifications, may be charged using charging sessions of the present application *(i.e.* , managed by dividing the charging session into one or more charging cycles) with minimal, or without requiring any modifications to the charging configurations of their batteries.

For example, according to some embodiments, whenever the received grid management instructions indicate that the supply of the electrical charging current to the charging device should be stopped, the charge spot issues respective signals, as defined according to some embodiments by the electric charging session management signaling scheme of the present application, to instruct the charging device to stop drawing electrical charging current therefrom. The charging device stops drawing electrical charging power upon receipt of these instruction signals, and then may issue signals to the charge spot indicating removal of the charging load, following which the charge spot terminates the charging cycle by electrically disconnecting supply of the charging power. A new charging cycle may be commenced by the charge spot, for example, upon receipt of grid management instructions permitting resumption of the electric charging power supply, following which the charge spot may issue signals to the charging device, as defined according to some embodiments by the electric charging session management signaling scheme, indicating a permissible maximum level of electrical charging power allowed. Responsively, if the charging device requires further charging, it issues respective signals, as defined in some possible embodiments by the electric charging session management signaling scheme and/or in the standards, indicating its intent to renew the consumption of electric charging power and resume the charging session by reconnecting the charging load and drawing the permissible charging power indicated by the charge spot.

One or more such charging cycles may be required in order to adequately charge a rechargeable battery. Once the charging device determines that its battery does not require any further charging, it electrically disconnects the charging load *(i.e.* , stops drawing electrical charging current) and indicates the same to the charge spot, which, responsively, electrically disconnects the supply of the electrical charging power to the charging device. Thereafter, the charging session may be terminated by mechanically disconnecting the connectivity *(e.g.* , connector of an electrical charging cable) between the charge spot and the charging device.

In some embodiments the charging device utilizes an on board communication module capable of communicating with the charge spot directly *(e.g.* , using wired communication such as utilizing modems, network adapters, or parallel or serial data buses, or wirelessly, such as utilizing Wi-Fi, Bluetooth or ZigBee), or indirectly *(e.g.* , using a data network, cellular network or via an operator server). For example, in electric vehicles, an on board communication module provided in the vehicle may be used to communicate between the vehicle and the charge spot, and also to communicate with a central control center *(e.g.* , of a service provider), and/or an operator server. The vehicle may be able to communicate its specific make and model to any of the entities communicatively coupled to it. The communicated information may be used by either the onboard communication module of the vehicle, by the operator server, or by the charge spot, to determine one or more suitable electric charging session management signaling schemes that the specific vehicle supports and that the charge spot may utilize to indicate commencement and resumption of charging cycles. The charge spot may then use one or more of the signaling schemes determined as suitable to indicate to the vehicle the need to electrically disconnect the charging load, and whenever possible, the ability to resume electric charging *(e.g.* , according to respective indications received over a communication network from the central control system, electric power supply network, service provider and/or operator server).

In other possible embodiments the user of the charging device may use an identification token *(e.g.* , RFID card, smart card, biometric signature, and suchlike), to be presented to the charge spot for the purpose of identification before starting a charging session. The identification token may include the identity of the user and/or identifying data about the charging device. The identification token may further include further identifying information about the make and model of the charging device, and/or about the electric charging session management signaling schemes supported by the charging device. The charge spot may be configured to identify the electric charging session management signaling schemes supported by the charging device by using the information provided directly from the identification token or by cross referencing it with information maintained in a database of users and/or their charging devices, stored in the control system *(e.g.,* hosted by an operator server). Based on the information maintained in the database, the charge spot may use any of the above described electric charging session management signaling schemes to indicate to the charging device the need to electrically disconnect from the electric charging supply, and whenever possible, about the ability to resume the charging session.

In some embodiments the charge spot is configured to employ different electric charging session management signaling schemes according to the signaling capabilities of the charging device. For example, some electric vehicles are configured to carry out a charging plan that discontinues charging completely until the vehicle is reactivated by the user, whenever the number of the discontinuities of the electric charging power supply is greater than a fixed number of electric charging power supply discontinuities allowed by the charging plan. The charge spot, or control system, controlling the charge spot, being aware of the limitations of the specific vehicle being charged, may be configured to adopt an electric charging session management signaling scheme supporting the charging plan that the vehicle is configured to perform, and to take into consideration this information. For example, the charge spot may adjust the charging session to include a minimal number of electrical disconnections of the electric charging power supply, so as to not exceed the number of charging discontinuities defined by the vehicle's charging plan.

In some possible embodiments the electric charging session management signaling schemes of the present application *(e.g.,* as exemplified hereinabove and hereinbelow) are jointly used *i.e.,* a charging pole may use some or all of the signaling schemes in sequence or use a specific method whenever information on the capabilities of the vehicle is available.

In some embodiments the charge spot is configured and operable to monitor the state of the charging load presented by the charging device *(e.g.* , by monitoring the state of the **SW2** switch shown in **Fig. 2),** and/or the actual current drawn by the charging device, to determine when to disconnect the electric charging current supply after completion of the signaling phase as described herein.

There is thus provided, according to one aspect of the present disclosure, a method for use in charging a battery of an electric vehicle comprising managing a charging session between a charge spot and a charging device of the battery. The method may include connecting between the charge spot and the charging device to enable the charge spot to perform a charging session during which electrical charging power is provided to the battery associated with the charging device, and selectively performing the charging session by a plurality of timely separated charging cycles, depending on data indicative of power management conditions or instructions. The plurality of timely separated charging cycles may comprise issuing signals to the charging device indicating commencement of a charging cycle, and issuing signals to the charging device indicating termination of said charging cycle based on the data indicative of a power network condition.

The power management conditions may include, for example, information relating to loads and/or demands for electrical power from an electric power network, that supplies the electrical charging power to the charge spot, during a certain period of time during a day, week, month or year *(e.g.* , high peaks of electrical power consumption during the summer between 11:00 to 17:00). Accordingly, information concerning power management conditions may be used by the charge spot to regulate the supply of the electric charging power based on electrical power consumption rates, and/or any other desirable parameter. Similarly, the charge spot may be configured to receive in real-time *(e.g.* , over wired communication links, and/or wirelessly) data indicative of power management instructions, and/or conditions, said data used by the charge spot for regulating the supply of the electric charging power to the charging device.

Additionally or alternatively, data indicative of power management conditions and/or instructions may be stored in a memory accessible by, or used in, the charge spot, to thereby allow the charge spot to autonomously determine regulation of the electrical charging power locally. For example, power management conditions and/or instructions may include a predetermined policy used in the charge spot to determine locally the regulation of the electrical charging power supplied to the charging device.

In a possible embodiment the charge spot is part of a power network comprising a plurality of communicatively coupled charge spots. In this case, the issuing of the signals indicating commencement of a charging cycle may be responsive to instructions received from the power network and/or from a central control system. Similarly, the signals indicating termination of a charging cycle may be responsive to instructions received from the power network and/or from a central control system. In some variants, the signals indicating commencement of a charging cycle are indicative of a permissible level of electric charging consumption power.

In some embodiments the method further comprises terminating the charging session by terminating consumption of the electrical charging power by the charging device, issuing signals to the charge spot indicating termination of consumption of the electrical charging power, and disconnecting the supply of the electric charging power by the charge spot.

The method may further comprise an initializing step for determining a suitable charging session management signaling scheme that defines signal patterns supported by the charging device and suitable for indicating the charging device at least termination of charging cycles, and possibly also commencement of charging cycles.

In some applications the initializing step is performed before starting the charging session. In such events the initializing step may include receiving identifying information of the charging device or of a user of said charging device, and based on the identifying information determining the suitable charging session management signaling scheme (*e.g.* , suitable for indicating at least the termination of charging cycles, and optionally also indicating commencement of new charging cycles).

Alternatively, the initializing step is performed after starting the charging session, and in such events the initializing step may comprise selectively issuing charging cycle termination signal patterns each belonging to a respective charging session management signaling scheme, and upon receiving from the charging device a signal pattern responsive to an issued charging cycle termination signal pattern, proceeding with the charging session using signal patterns defined in the respective charging session management signaling scheme to indicate termination and commencement of charging cycles. Alternatively, proceeding with the charging session is carried out upon sensing that the charging device stopped consumption of the electrical charging power in response to a specific signal pattern, in which case the signal patterns defined in the respective charging session management signaling scheme are used to indicate termination and commencement of charging cycles.

The method may further comprise receiving *(e.g.* , from the power network and/or the central control system) data comprising electric power supply regulating instructions, issuing signals to the charging device indicative of the electric power supply regulating instructions, and responsively at the charging device, regulating the consumption of electric charging power according to the issued signals.

In another aspect of the present disclosure, there is provided a charger apparatus configured and operable to manage electrical connection of electrical charging power to a charging device. The charger apparatus may comprise at least one connector suitable for at least supplying electric charging power to the charging device, a source of electric charging power connectable to the connector, and a processing utility configured to electrically connect and disconnect between the source of electric charging power and the at least one connector and to selectively perform at least one charging session by a plurality of timely separated charging cycles. Optionally, the plurality of charging cycles are selectively performed responsive to data indicative of power management conditions or instructions received over a communication network or stored locally in a memory of the charging spot.

The charger apparatus may further comprise a communication module for communicatively linking the charger apparatus with a central control center and/or the electric power supply network. In a variant, the processor utility is configured to manage the timely separated charging cycles by the issue of signals to the charging device indicating commencement of a charging cycle and signals indicating termination of a charging cycle, based on the condition of the electric power supply network. Optionally, the processor utility may be configured to encode a permissible level of electric charging consumption power in the signals indicating commencement of a charging cycle.

The charger apparatus may further comprise an input device configured to receive data from at least one of the following: the charging device; a user of the charging device; an identifying token carried by the user or by the charging device.

In some applications, the processor utility is configured to determine a suitable charging session management signaling scheme defining signal patterns supported by the charging device and suitable for indicating to the charging device at least the termination of a charging cycle, and optionally also the commencement of a charging cycle. The processor utility may be configured to determine the suitable charging session management signaling scheme based at least in part on data received from the communication module or from the input device. Alternatively, the processor utility is configured to determine the suitable charging session management signaling scheme after starting a charging session by successively issuing charging cycle termination signal patterns each belonging to a respective charging session management signaling scheme, and choosing the respective charging session management signaling scheme upon receipt of a responsive signal pattern from the charging device or upon sensing that the charging device ceased consumption of the electrical charging power in response to a specific signal pattern.

Optionally, the charging device is part of, or used in, an at least partially electric vehicle. The processor utility may be configured to receive data comprising electric power supply regulating instructions over a communication or data network *(e.g.* , from the central control system and/or the electric power supply network), and issue signals to the charging device indicative of the electric power supply regulating instructions, thereby allowing the charging device to regulate consumption of electric charging power according to the issued signals.

According to yet another aspect, the present application is directed to an electric charge spot network, comprising a plurality of charge spots connectable to charging devices and configured to controllably supply the charging devices electric charging power and communicate a plurality of signals therewith. The charge spots of the electric charge spot network may be configured to receive data indicative of power management conditions or instructions, and issue, based on said power management conditions or instructions, signals indicative of commencement or termination of charging cycles, for regulating the supply of the electric charging power based on the data received.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the invention and to see how it may be carried out in practice, embodiments will now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which same reference numerals are used to identify elements or acts with the same or similar functionality, and in which:

Fig. 1 schematically illustrates an electric charging network and power network according to possible embodiments;

Fig. 2 schematically illustrates standard connectivity between a charging device and a charge spot;

Fig. 3 exemplifies a basic signaling scheme between a charging device and a charge spot;

Figs. 4 to **7** exemplify possible electric charging session management signaling schemes according to some possible embodiments; and

Figs. 8A and **8B** are event trace diagrams illustrating methods of determining according to possible embodiments suitable electric charging session management signaling schemes supported by the charging device.

DETAILED DESCRIPTION OF EMBODIMENTS

Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings. In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the present application. However, it will be apparent to one of ordinary skill in the art that the subject matter of present application may be practiced without these specific details. In other instances, well-known methods, procedures, components, circuits, and networks have not been described in detail so as not to unnecessarily obscure aspects of the embodiments.

In the exemplary embodiments described hereinbelow reference is made to charging session of an at least partially electric vehicle. It is however noted that the present invention is not limited to the charging of batteries of electrical vehicles, and that embodiments of the present application may be employed in charging sessions *(e.g.* , heavy-duty chargers) of any chargeable device or machinery powered by rechargeable batteries, or any other such electrically renewable power source, and that is able to communicate with a charging spot (also referred to herein as a charger apparatus) over a signaling line.

Fig. 1 illustrates an electric charging network **100,** according to some possible embodiments, which includes a plurality of charging devices **102** *(e.g.* , electric vehicles) each having a chargeable battery 104. The battery 104 may include any suitable electric energy storing means, such as, but not limited to, chargeable batteries *(e.g.* , lithium ion batteries, lead-acid batteries, nickel-metal hydride batteries, etc.), capacitors, reaction cells (e.g., Zn-air cell), and such like. For example, in some embodiments the charging devices 102 are electric vehicles each including an electric motor 103 that drives one or more wheels of the vehicle. In these embodiments, the electric motor 103 receives energy from a battery *(e.g.* , the battery 104) that is electrically connected to the vehicle (shown separate from the vehicle in **Fig.** 1 for ease of explanation).

In some of these exemplary embodiments the vehicle 102 further includes a positioning system 105 *(e.g.* , GPS, or any other satellite or cellular triangulation positioning system) capable of determining the geographic location of the vehicle 102, and possibly also of determining a driving route suitable for reaching a desired target destination of the user 110. The charging device 102 may further include an on board communication module 114 *(e.g.* , wireless communication, such as RF cellular communication), allowing it to communicate data with a central control system (designated in **Fig.l** as service provider) 112, with the battery exchange station 108, and/or with the charge spot 106, over the data network 120.

In some of these exemplary embodiments, the battery 104 can be charged at a charge spot 106, also known as a charger apparatus. In some embodiments a collection of charge spots (charger apparatuses), collectively referred to as a charge station 106, may be installed in a specific geographic location and used to provide battery charging services to vehicles. In some possible embodiments, the charge spots 106 provide energy to the charging device 102 to charge the battery 104 of the charging device 102. In the case of electric vehicles, for example, charge spots 106 may be situated at any location wherein the vehicles may be parked or have stopped to recharge their batteries. For example, the charge stations 106 may be located in parking lots of office buildings or shopping centers and/or near street parking spots. In some embodiments, a charge spot 106 may be located at a household of a user *(e.g.* , the home 130). In some embodiments, the charge spot 106 may charge the battery 104 at different rates. For example, the charge spots 106 may charge the battery 104 using a quick-charge mode or a trickle charge mode.

In some embodiments, the battery 104 can be exchanged for a charged battery at one or more battery exchange stations 108. In the case of electric vehicles, if the user

110 of the vehicle is traveling a distance beyond the range of a single charge of the battery **104** of the vehicle, the discharged (or partially discharged) battery can be exchanged for a replenished battery so that the user can proceed traveling without waiting for the battery to be recharged.

In some embodiments, the charging device **102** includes a communication module **114.** The charging device **102** may include hardware and software used to communicate with a service provider **112** of a charge spots network **100** (also referred to herein as electric charging network) of the present application. It is noted that the term "charge spots network" is used herein to refer to a network in which at least one battery charge spot **106** and a service provider **112** are communicatively coupled, for example, over a data network **120.** In some possible embodiments the charge spots network **100** may also include one or more battery exchange stations **108,** and one or more battery charge stations **106.** The charge spots network **100** may also include one or more charging devices **102,** each having at least one chargeable battery **104.**

In some embodiments, the service provider **112** obtains information about the devices **102** and/or the charge spots **106** and battery exchange stations **108** by sending queries through a data network **120** to the devices **102,** the charge spots **106,** and/or the battery exchange stations **108.** For example, the service provider **112** can query the charging devices **102** to determine their geographic locations and the status of their batteries. Similarly, the service provider **112** may query the charge spots **106,** and/or the battery exchange stations **108,** to determine their statuses *(e.g.* , occupied or freed).

The service provider **112** can also send information and/or commands through the data network **120** to the charging devices **102,** the charge spots **106,** and/or the battery exchange stations **108.** For example, the service provider **112** can send information, to the charging devices **102,** about a status of an account of the user **110,** the locations of battery service stations **(106** and/or **108),** and/or about their statuses.

In some possible embodiments the electric charge spot network **100** also includes the data network **120** and a power network **140.**

The data network **120** may include any type of wired or wireless communication network capable of communicatively coupling communication nodes. This includes, but is not limited to, a local area network, a wide area network, or a combination of networks. In some embodiments, the data network **120** is a wireless data network including: a cellular network, a Wi-Fi network, a WiMAX network, an EDGE network, a GPRS network, an EV-DO network, an RTT network, a HSPA network, a UTMS network, a Flash-OFDM network, an iBurst network, and any combination of the aforementioned networks. In some embodiments, the data network **120** includes the Internet.

As illustrated in **Fig. 1,** the data network **120** may be communicatively coupled to the charging devices **102,** to the service provider **112,** to the charge spots **106,** to the power network **140** and/or to the battery exchange stations **108.** However, in possible embodiments the data network **120** is used to communicatively couple at least between the central control system **112** and the charge spots and/or charge stations **106.**

It is noted that only one charging device **102** (illustrated as a vehicle in **Fig. 1),** one battery **104,** one charge station **106** and one battery exchange station **108** are illustrated, for the sake of clarity, and that the electric charging network **100** may include any number of charging devices **102,** batteries **104,** charge stations **106,** and/or battery exchange stations **108,** etc. Furthermore, the electric charge spot network **100** may include zero or more battery exchange stations **108.** For example, the electric charging network **100** may just include one or more charge spots **106.** In some embodiments, any of the charging devices **102,** the service provider **112,** the charge spots **106,** and/or the battery exchange stations **108,** includes a communication module that can be used to communicate with each other through the data network **120.**

The power network **140** may include power generators **156,** power transmission lines, power substations, transformers, etc., which facilitate the generation and transmission of electric power to the various battery charging facilities. The power generators **156** may include any type of energy generation plants, such as wind-powered plants **150,** fossil-fuel powered plants **152,** solar powered plants **154,** biofuel powered plants, nuclear powered plants, wave powered plants, geothermal powered plants, natural gas powered plants, hydroelectric powered plants, and a combination of the aforementioned power plants or the like. The energy generated by the one or more power generators **156** may be distributed through the power network **140** to homes **130,** charge spots **106,** and/or battery exchange stations **108.** The power network **140** can also include batteries such as the battery **104** of the charging devices **102,** batteries at battery exchange stations **108,** and/or batteries that are not associated with charging devices **102.** Thus, energy generated by the power generators **156** can be stored in these batteries and extracted thereafter when energy demand exceeds the amount of generated energy that can be supplied by the power network at a specific point in time.

With reference to **Fig. 2,** in a typical charging session, a charge spot **106** may be connected to a charging device **102** (hereinafter vehicle **102)** using a standard connector and cable **14,** as defined by the specification of the IEC61 85 1 standard, for example. As part of the connection **14** a pilot signal line **106p** is connected between the charge spot **106** and vehicle **102** that allows the charge spot **106** to control the charging session and regulate the supply of the electric charging power. A control unit **106c** is used in the charge spot **106** to drive voltage signals on the pilot line **106p,** and measure the voltage **Va** over a resistive element **Rl** provided on the pilot line **106p.** The voltage signals applied over the pilot line **106p** are controllably changed by the control unit **106c** by means of a switch circuitry **SW1,** that arbitrates between a fixed 12V signal and a pulsating +12V voltage signal that is modulated (PWM) by the control unit **106c** to provide indications about the permissible electrical charging currents that can be drawn by the vehicle **102** over the electric power supply line **10.** The control unit **106c** may also control the electrical connectivity of the electric power supply line **10** to the connector **14** using the switching circuitry **106r** controllably coupled thereto.

A battery charge controller **102c** is used in vehicle **102** to receive indications from the charge spot over the pilot line **106p** through a buffering circuitry **102b,** and to alter the electrical resistance over the pilot line **106p** by controllably changing the state of the switching circuitry **SW2.** The pilot signal is typically received through a diode **D** at the vehicle side, such that battery charge controller **102c** actually may be capable of sensing only the positive part of the pilot signals. The battery charge controller **102c** measures the duty cycle of the signals received over the pilot line **106p** and accordingly activates the charger unit **102g** to draw permissible electric charging power over the supply line **10** for charging the battery **104.**

The control units, **102c** and **106c,** may be implemented employing any suitable combination of processing units *(e.g.* , CPU, MCU, and suchlike) and memory units *(e.g.* , RAM, ROM, EPROM, FLASH, and suchlike) as known to persons skilled in the art. The charge spot **106** may be implemented using various approaches based on the schematic structure exemplified in **Fig. 2** and such as described in international patent publication No. WO 2012/007784, of the same applicant hereof, the disclosure of which is incorporated herein by reference.

Fig. 3 is a voltage diagram demonstrating a conventional charging session **30** *e.g.,* complying with the IEC61851 standard specification. Before establishing connection **(SI)** with the vehicle **102,** using the connector **14,** the charge spot **106** (referred to as EVSE in the standard) supplies a constant 12V signal on the pilot line **106p.** The constant 12V voltage is supplied through the fixed resistor **Rl,** for example by setting the **SW1** switch into a standby state. Once a connection is made **(S2)** between the charge spot **106** and the vehicle **102,** a circuit is closed connecting the pilot line **106p** to the **GND** *{i.e.,* electrical ground) at the vehicle side through the **Rl** and **R2** serially connected resistors, causing the voltage **Va** observed by the charge spot **106** to drop to 9V. The voltage drop is sensed by the control unit **106c** of the charge spot **106** which in turn changes the state of the **SW1** switch into a signaling state and starts driving a PWM signal **(S3)** on the pilot line **106p.** The PWM duty cycle applied by the control unit **106c** over the pilot line **106p** indicates to the battery charge controller **102c** the maximal permissible electrical current that the charge pole **106** can supply to the vehicle **102** over the electrical supply line **10.**

In turn, the battery charge controller **102c** of vehicle **102** signals **(S4)** its intent to draw current by altering the state of switch **SW2** to connect an additional resistor **R3** to **GND** in parallel to resistor **R2** (hereinafter referred to as a charging state). The battery charge controller **102c** detects the PWM signal over the pilot line **106p** and decodes therefrom the permissible electric charging current that the charger **102g** is allowed to draw for the recharging of the battery **104.**

The parallel connection of the resistor **R3** causes the positive part of the pilot signal **Va** sensed by the control unit **106c** of charge spot **106** to drop from 9V to 3V (or 6V, depending on mode of operation). In response to this voltage drop the control unit **106c** of charge spot **106** connects the electric power supply **V (AC)** over the supply line **10** to connector **14** by changing the state of the switching circuitry **106r (S5).** The vehicle **102** then starts drawing electric current from the charge spot **(S6),** not in excess of the permissible maximal current indicated by the charge pole **106** by the PWM pilot signal.

During the charging session **30** the charge spot **106** may decide to change the permissible maximal current limitation by changing the duty cycle **(S7)** of the PWM signal. The battery charge controller **102c** of vehicle **102** senses this change in the PWM signal on the pilot line **106p,** and adjusts the maximal current drawn **(S8)** by the charger **102g,** accordingly.

Whenever there is a need at the vehicle **102** side to terminate the charging cycle **30** *(e.g.,* responsive to instructions from the user **110),** the battery charge controller **102c** stops the charging and current draw **(S9),** and indicates the completion of the charging session **(S10)** by changing the state of the **SW2** switch into a standby state, thereby disconnecting the additional parallel resistor **R3.** This in turn causes the positive voltage of the PWM signal **Va** to go up back to 9V. The control unit **106c** of the charge spot **106** senses the change in the voltage of the signal over the pilot line **106p** and alters the state **(Sll)** of the switching circuitry **106r,** thereby disconnecting the power supply over the electric power supply line **10.**

The charging session **30** is completed when the mechanical and electrical connection obtained by the charging cable connector **14,** connecting the charge spot **106** and the vehicle **102,** is removed **(S12),** and the voltage **Va** sensed by the control unit **106c** on the pilot line **106p** goes back to 12V. The control unit **106c** of the charge spot **106** senses the change in the voltage signal over the pilot line **106p** and responsively completes the charging session **30** by stopping the PWM signal modulation **(S13)** and altering the state of the **SW1** switch into a standby state.

Although the standard charging procedure allows the charge spot **106** to control the current level drawn by the vehicle **102,** it does not allow charging session termination to be initiated by the charge spot **106,** or discontinuities in the electric power supply of the electric charging current. The present invention, in some of its embodiments, provides electric charging session management signaling schemes that allow the charge spot **106** to indicate to the vehicle **102** that a charging cycle is to be terminated, and thereafter, if possible, that the charging may be resumed *(i.e.,* that a new charging cycle may be commenced), without physically removing the charging cable **14** connected thereto.

A few possible electric charging session management signaling schemes according to possible embodiments may be used to signal the vehicle **102** the charge spot's intent to terminate a charging cycle. **Fig. 4** diagrammatically exemplifies a possible electric charging session management signaling scheme used in an exemplary charging session **40** according one possible embodiment. Steps **SI** to **S6** in **Fig. 4,** which initiate the charging session **40,** are substantially similar to the same steps defined in the standard, as exemplified in **Fig. 3** and described hereinabove, and for the sake of brevity will not be discussed again.

After steps **S1-S6** a charging cycle **40a** of the charging session **40** is active. In this example, when the charge spot **106** wishes to terminate a charging cycle its control unit **106c** modifies the PWM duty cycle to 5% **(S17).** This specific duty cycle is reserved in the standard specification for signaling the vehicle **102** of the existence of an additional serial signaling channel between the charge spot **106** and the vehicle **102.** Upon receipt of such signaling battery charge controller **102c** of vehicle **102** stops the drawing of the charging current and waits for the establishment of a serial connection.

In this example, a vehicle **102** with a battery charge controller **102c** which complies with the electric charging session management signaling scheme of this embodiment, stops the current draw **(S18),** and then disconnects the additional parallel resistor **R3** **(S19)** to indicate to the control unit **106c** of the charge spot **106** the termination of the charging cycle, which may then terminate the charging cycle **40a** by disconnecting the electric power supply **10** **(S20).**

The charge spot **106** may signal resumption of the charging session **40** by modifying the duty cycle of the PWM pilot signal to a duty cycle within the valid range of 8%-97% **(S21).** During the time period between the termination **S20** and resumption **S21** of the charging session the PWM remains in the 5% duty cycle. Once the modified duty cycle **(S21)** is noticed by the battery charge controller **102c** of the vehicle **102,** and in case further charging is needed, the battery charge controller **102c** reconnects the parallel resistor **R3** **(S22)** to indicate to the control unit **106c** of the charge spot **106** its intent to start a new charging cycle **40b** and to draw electrical charging current from the charge spot. Responsively, the control unit **106c** reconnects the power supply **(S23)** to the electric power supply line **10** and the permissible charging current $\mathbf{I_{(AC)}}$ indicated by the PWM duty cycle of the pilot signal is then drawn **(S24)** by the charger **102g.**

The control unit **106c** of the charge spot **106** may stop and resume the charging process numerous times during the charging session **40** by terminating active charging cycles whenever needed, and commencing new charging cycles whenever it determines that electric charging is permitted. For example, control unit **106c** may receive grid management instructions from the power network **140** over data network **120** indicating that the electric charging power should be disconnected, and in response control unit **106c** may issue corresponding signals **(S17)** to instruct the battery charging controller

102c to stop drawing electric charging current. During the charging session **40** the control unit **106c** may receive from the power network **140** grid management instructions indicating that electric charging may be resumed, if so needed, and in response the control unit **106c** indicates **(S21)** to the battery charge controller **102c** that the electric charging can be resumed.

In some possible embodiments data indicative of the grid management instructions is sent from the power network **140** to the central control system **112** of the electric charge spot network **100** over the data network **120.** The central control system **112** may be configured to analyze the grid management instructions received from the power network **140,** and based thereon to selectively instruct one or more charge spots and/or charge stations **106** to temporarily stop active charging processes *(i.e.,* to terminate active charging cycles). In a similar way, the central control system **112** may selectively instruct one or more battery exchange stations **108** and/or specific charger apparatuses used in the battery exchange stations **108** or in households **130,** to temporarily stop active charging processes. In addition, the central control system **112** may be configured to selectively send grid management instructions to the charge spots/stations **106,** exchange stations **108,** and/or chargers installed in households **130,** based on a predefined grid management policy *e.g.,* defined by a service provider or energy supply/control agency, without receipt of such instructions from the power network.

Additionally or alternatively, the charge spot **106** may be configured to autonomously determine the regulation of the electrical charging power supplied to the vehicle **102,** locally. For example, data indicative of power management conditions and/or instructions may be stored in a memory of the charging spot **106** and used by the charge spot to determine locally the termination of active charging cycles and commencement of new charging cycles. The power management conditions and/or instructions may include a predetermined policy used by the charge spot to determine locally the regulation of electrical charging power supplied to the charging device.

Another possible embodiment is exemplified in **Fig. 5,** wherein steps **SI** to **S6** commencing the charging cycle **50a** of the charging session **50** are also substantially similar to the same steps demonstrated in **Fig. 3,** as described hereinabove, and for the sake of brevity will not be described herein again. In **Fig. 5,** exemplifying another possible electric charging session management signaling scheme of the present disclosure, the charge spot **106** signals **(S27)** its intent to terminate the charging cycle **50a** by driving the voltage on the pilot line **106p** to a fixed 12V *(i.e.,* PWM with duty cycle of 100%) *e.g.,* using the **SW1** switch. Responsively, the voltage on the pilot line **106p** is changed into 3V/6V due to the parallel connection of the additional resistors **R3** on the vehicle side. The rest of the steps in this example **(S19** to **S24)** are substantially similar to the same steps depicted in **Fig. 4,** as described hereinabove. A vehicle **102** whose battery charge controller **102c** supports this embodiment is configured to stop the charging cycle **50a (S18)** and to signal the control unit **106c** of the charge spot **106** the completion of the charging cycle by disconnecting the parallel resistor **R3 (SI 9).** The control unit **106c** of the charge spot **106** then disconnects the electrical power supply **(S20).** Resumption of the charging session, by initiating a new charging cycle **50b** in steps **S21** to **S24,** is substantially similar to the same process steps demonstrated in **Fig. 4** as described hereinabove.

In **Fig. 6,** which exemplifies another possible electric charging session management signaling scheme of the present application, the charge spot **106** is configured to signal its intent to terminate an active charging cycle **60a** of a charging session **60** by driving the pilot line **106p** to a fixed -12V (0% duty cycle) **(S37).** Upon sensing this signal *e.g.,* if the sensing circuitry is behind the diode **D** a 0V signal is sensed, a vehicle **102** whose battery charge controller **102c** supports the signaling scheme of this embodiment, stops the charging cycle **60a (S18)** and disconnects the parallel resistor **R3 (S19).** In this example the control unit **106c** of the charge spot **106** has no way of sensing the change of state in the pilot resistance circuitry at the vehicle side since all negative voltages applied by the control unit **106c** are cut off by the diode **D** at the vehicle side **102,** and are not loaded by the resistors. Accordingly, the change in resistor connection state at the vehicle side **102** does not influence the signal on the pilot line **106p** at the charge pole side **106,** and it is therefore not sensed by its control unit **106c.** In this case the control unit **106c** of the charge spot **106** may disconnect the power supply **(S40)** after a fixed predefined delay T_{delay} time period that should allow the battery charge controller **102c** of the vehicle **102** to terminate its current draw.

The commencement of a new charging cycle **60b** in steps **S21** to **24,** used for the resumption of the charging session **60,** is substantially similar to the same steps exemplified in **Fig. 4,** as described hereinabove (the PWM signal remains in the -12v level between the termination **S37** and resumption **S21** of the charging session). The steps **SI** to **S6** in **Fig. 6** commencing the charging cycle **60a** of charging session **60** are also substantially similar to the same steps demonstrated in **Fig. 3,** as described hereinabove.

In **Fig. 7,** which exemplifies yet another possible electric charging session management signaling scheme of the present application, the control unit **106c** of the charge spot **106** is configured to signal its intent to terminate a charging cycle **70a** in a charging session **70** by driving the signal on the pilot line **106p** to a fixed 0V **(S47)** for a predefined minimum period of time T_{deiay}, and to disconnect the electrical charging power supply thereafter **(S50).** A vehicle **102** whose battery charge controller **102c** is configured to support the signaling scheme of this embodiment detects this signaling as a cable unplug event, and responsively stops the charging cycle **70a (S18)** and disconnects the parallel resistor **R3 (S19).** In this example, when the control unit **106c** of the charge spot **106** wishes to start a new charging session **70b** and resume charging, it drives the pilot signal to 12V **(S51)** and then uses the conventional PWM pilot signaling to indicate to the battery charge controller **102c** of the vehicle **102** that charging session can be resumed. A vehicle **102** which control unit **102c** supports the signaling scheme of this embodiment, then connects the parallel resistor **R3 (S52)** and drives the pilot voltage to 6V (or 3V). The control unit **106c** of the charge spot **106** may be configured to determine if the specific vehicle **102** has correctly detected the 0V signaling as disconnect event, by testing that the maximal voltage level of the reapplied PWM signal is actually 6V (or 3V) (and not 9V).

The steps **SI** to **S6** commencing charging cycle **70a** of charging session **70** in **Fig. 7** are also substantially similar to the same steps demonstrated in **Fig. 3,** as described hereinabove.

It is noted that some of the signaling methods described hereinabove are not defined in the standards, and thus some of the charging devices may support all, part, or none, of these methods. The support of each of these methods depends on the specific implementation as defined by the individual manufacturers of the charging devices.

In order to overcome this limitation, in possible embodiments information may be sent from the on board communication module **114** of the charging device **102** to the charge spot **106** or service provider **112** to identify the exact type of charging device **102** *(e.g.* , brand and model of electric vehicle) currently connected to the charge spot **106.** Based on the identifying information the control unit **106c** of the charge spot **106** may derive the specific signaling scheme to be used to manage the charging session *e.g.*, by initiating one or more charging cycles in the charging session, if so needed. The signaling scheme used may be any one of the above described methods or any other method. For example, new and different signaling schemes that are specific to certain electric vehicles may be selected based on identifying information received from the vehicle. Mapping information for associating types of charging devices with specific electric charging session management signaling schemes they support may be stored on an on board communication module provided in the vehicle, in an operator server (not shown), or in the charge spot **106.**

In some embodiments the on board communication module **114** of the charging device **102** communicates directly with the charge spot **106,** via wired or wireless communication and provides it with information on the specific model and make of the charging device **102.** The charge spot **106** may use this information to determine the type of electric charging session management signaling schemes supported by the battery charge controller **102c** of the charging device **102** to be serviced. Alternatively, the on board communication module **114** of the charging device **102** may be adapted to directly indicate the charge spot **106** and/or the central management system **112** the specific electric charging session management signaling schemes which are supported by the vehicle **102.**

For example, the electric charging session management signaling schemes supported by the charging device **102** may be transmitted by the on board communication module **114** to the charge spot **106** and/or the central management system **112** over the data network **120.** In possible embodiments the charge spot includes a communication module **106t** (wired or wireless), and the on board communication module **114** may be adapted to communicate with the charge spot directly *{e.g.*, wirelessly, using Wi-Fi, Bluetooth, or ZigBee communication unit, or wired communication using a modem, network card, or serial or parallel data bus), and provide it with data indicative of the electric charging session management signaling schemes supported by the charging device during, or after, the vehicle **102** approaches the charge spot **106.**

Fig. 8A is an event trace diagram illustrating a possible embodiment wherein data indicative of the signaling schemes supported by the charging device **102** is transmitted to the charge spot **106** before or during commencement of the charging session. In this example the charging device **102** may send the data indicative of the electric charging session management signaling schemes **(80)** supported by it together with identifying data *(e.g.* , device manufacturer and model, and/or serial number) to the service provider **112** (indicated as control center in **Fig. 8A)** any time before starting a charging session.

Referring now to **Fig. 1,** in some embodiments service provider **112** hosts and manages a database **40** comprising a plurality of data records **42** each relating to a specific charging device **102.** For example, each data record **42** may include identifying information **42a** about the charging device **102** and/or about its user **110,** data indicative of the electric charging session management signaling schemes **42b** supported by the vehicle **102,** and additional data **42c** as may be required *(e.g.* , history of previous charging events, information about rechargeable batteries previously used by the charging device, and suchlike). The service provider **112** may be adapted to receive the information **42a 42b** and **42c** sent from the charging device **102** and record the same in a specific data record **42** in the database **40.**

Whenever a charging device **102** approaches a charge spot **106** it may send identifying information **(81)** about the charging device **102** to the charge spot **106.** Upon receipt of the identifying data the charge spot **106** may send a request **(82)** to the service provider **112** for providing it with data **42b** indicative of the electric charging session management signaling schemes supported by the charging device **102,** based on the received identifying information. The service provider **112** may then search in the database **40** for a data record **42** associated with the charging device **102,** and send a response **(83)** to the charge spot **106** with the data **42b** indicative of the electric charging session management signaling schemes supported by the charging device **102,** and any additional data **42c** about the charging device **102** and/or its battery **104,** as may be needed.

Optionally, the service provider **112** sends to the charge spot **106** the entire data record **42** matching to the identifying information of the user **110** and/or the charging device **102,** as received therein in the request **81.**

Alternatively, data **42b** indicative of the electric charging session management signaling schemes supported by the charging device **102** is transmitted **(84)** to the charge spot **106** by the charging device **102** before or during commencement of the charging session. The charge spot may send **(85)** the received information to the service provider **112** to update the database **40.**

In some possible embodiments the charge spot **106** includes a user interface module **(106m** in **Fig. 1)** that enables it to receive an identification token of the user **110** *e.g.,* using a RFID card, a smart card, or a biometric signature. The charge spot **106** may be adapted to receive the identifying information from the identification token, and optionally verify it with the service provider **112** (or operator server). For example, the identifying information sent in step **82** in **Fig. 8A** from the charge spot to the service provider **112** may include identifying information of the user **110** of the charging device **102,** and the database **40** may be configured to find the specific data record **42** of the respective charging device **102** according to the received identifying information of the user **110.**

The identity token received in the charge spot **106** via the user interface module **(106m)** may also include information on the charging device **102** of the user **110** and its make, and/or data **42b** indicative of the electric charging session management signaling schemes supported by the charging device **102.** Alternatively, this information can be derived by the charge spot **106** by communicating an operator server (not shown) hosting the database **40** and capable of matching between users **110** and vehicles **102** according to the received identifying information.

The charge spot **106** then uses the specific supported electric charging session management signaling schemes to signal any discontinuities in the charging session based on the data **(42b)** received **(83)** from the service provider **112** and/or power network **140.** For example, once connection is established **(S2)** with the charging device **102,** the charge spot may indicate **(S3)** the charging device **102** the permissible charging power that can be drawn from the grid, and the charging device **102** may then indicate its intent to connect the charging load **(S4).** Thereafter, the charge spot **106** connects the electrical charging power **(S5)** and the charging device **102** draws the permissible electrical charging power, and whenever there is a need for the charge spot **106** to disconnect the electrical charging power it will indicate so using one of the signaling schemes **(S17, S27, S37** or **S47)** supported by the charging device **102.** In response, the charging device **102** will disconnect the charging load and indicate the same **(S19)** by altering the state of the **SW2** switch. During the charging session any number of charging cycles may be terminated **(S17, S27, S37** or **S47)** and recommenced **(S21** to

S24), as may be required by central control system **112** and/or the power network **140,** until the battery of the charging device is adequately charged. With reference to **Fig. 8B,** in possible embodiments, the charge spot **106** may be adapted to test some or all of the electric charging session management signaling schemes with the specific charging device **102** connected thereto, and record the response of the charging device **102** *(i.e.,* if it stopped charging when signaled, and resumed charging after pilot signal indicating charging has been reapplied) for future usage with that specific vehicle. For example, such a charging session may include provision of identifying information **(86)** about the user **110** and/or its charging device **102,** followed by the standard steps **(S2** to **S5)** for commencing the first charging cycle. Thereafter, the charge spot may issue pilot signals indicating the need to terminate the charging cycles by changing the duty cycle of the PWM signals to 5% or 100% **(S17** or **S27).** If the charging device **102** complies with any of these signaling schemes it will indicate so by altering the state of the **SW2** switch **(S19),** and the charge spot **106** will then record data indicative of the electric charging session management signaling schemes supported by the charging device **102,** and proceed with the charging session accordingly. The recorded data concerning the signaling schemes supported by the charging device **102** may also be sent **(87)** to the control center **112** for recordal in the database **40** for future usage in any same or other location of charging spots **106.**

If the charging device **102** does not comply with 5% or 100% duty cycle **(S17** or **S27)** signaling schemes, the charge spot may further test if it supports the 0% duty cycle or 0V signaling schemes **(S37** or **S47).** If the charging vehicle **102** complies with any of these signaling schemes by removing the charging load **(S18)** and/or by disconnecting the **R3** resistor **(S19),** then the charge spot **106** records data indicative of the supported signaling scheme and proceeds with the charging session accordingly. The recorded data concerning the signaling schemes supported by the charging device **102** may also be sent **(87)** to the control center **112** for recordal in the database **40** for future usage in any same or other location of charging spots **106.**

Some charging devices **102** may not support any of the signaling schemes of the present application. Namely, such charging devices **102** may not accept the controlled termination of a charging session by the charge spot **106,** and thus may require physical plug out of the charging cable **14** and reinsertion thereof in order to re-initiate the charging process. A charge spot **106** that supports this type of charging device **102** should take this limitation into consideration and modify the charging plan accordingly. Such modifications may include maintenance of minimal current supply to the specific charging device 102 throughout the charging session.

Accordingly, in some possible embodiments a charging session may include a plurality of charging cycles, wherein the electrical charging power between one or more of the charging cycles is reduced to a predefined minimal electrical charging power (*i.e.,* instead of temporarily disconnecting the electrical charging power). As explained above, for certain types of electric vehicles a limited number of electric power disconnections may be permitted, and thus the charger apparatus 106 of the present application may be configured to reduce the electrical charging power to a predefined minimum responsive to grid management instructions received from the central control center 112 and/or the power network 140.

The above examples and description have of course been provided only for the purpose of illustration, and are not intended to limit the invention in any way. As will be appreciated by the skilled person, the invention can be carried out in a great variety of ways, employing more than one technique from those described above, all without exceeding the scope of the invention.

CLAIMS:

1. A method for use in charging a battery of an electric vehicle, the method comprising managing a charging session between a charge spot and a charging device of the battery, said managing comprising:

connecting between said charge spot and said charging device to enable the charge spot to perform a charging session for providing electrical charging power to the battery associated with said charging device; and

selectively performing the charging session by a plurality of timely separated charging cycles, depending on data indicative of power management conditions or instructions.

2. A method according to claim 1, wherein each of the plurality of timely separated charging cycles comprises:

issuing signals to the charging device indicating commencement of a charging cycle, and

issuing signals to the charging device indicating termination of said charging cycle.

3. A method according to claim 2, wherein the signals indicating termination of the charging cycle comprises at least one of the following signals:

5% duty cycle pilot;

100% duty cycle pilot;

0% duty cycle pilot; and

0 Volts pilot signal.

4. A method according to any one of claims 1 to 3, wherein the charge spot is part of a power network comprising a plurality of communicatively coupled charge spots.

5. A method according to claim 4, wherein the issuing of the signals indicating commencement of a charging cycle is responsive to instructions received over the network.

6. A method according to any one of claims 2 to 5, wherein the signals indicating commencement of a charging cycle are indicative of a permissible level of electric charging consumption power.

7. A method according to any one of claims 4 to 6, wherein the issuing of the signals indicating termination of a charging cycle is responsive to instructions received over the network.

8. A method according to any one of the preceding claims, further comprising terminating the charging session, as follows:

stopping consumption of the electrical charging power by the charging device;

issuing signals to the charge spot indicating stopping of consumption of the electrical charging power; and

disconnecting the supply of the electric charging power by the charge spot.

9. A method according to any one of the preceding claims, further comprising an initializing step for determining a suitable charging session management signaling scheme, said suitable charging session management signaling scheme defining signal patterns supported by the charging device and suitable for indicating to the charging device at least termination of a charging cycle.

10. A method according to claim 9, wherein the initializing step is performed before starting the charging session.

11. A method according to claim 9 or 10, wherein the initializing step includes:

receiving identifying information of the charging device or of a user of said charging device; and

based on said identifying information determining the suitable charging session management signaling scheme.

12. A method according to claim 9, wherein the initializing step is performed after starting the charging session, and wherein said initializing step comprises selectively issuing charging cycle termination signal patterns, each of said charging cycle termination signal patterns belonging to a respective charging session management signaling scheme, and upon receiving from the charging device a signal pattern responsive to an issued charging cycle termination signal pattern, proceeding with said charging session using signals patterns defined in the respective charging session management signaling scheme.

13. A method according to claim 9, wherein the initializing step is performed after starting the charging session, comprising successively issuing charging cycle termination signal patterns, each of said charging cycle termination signal patterns belonging to a respective charging session management signaling scheme, and upon sensing that the charging device stopped consumption of the electrical charging power, proceeding with said charging session using signals patterns defined in the respective charging session management signaling scheme.

14. A method according to any one of claims 1 to 13, further comprising:

receiving data indicative of electric power supply regulating instructions;

issuing signals to the charging device indicative of said electric power supply regulating instructions; and responsively at the charging device

regulating the consumption of electric charging power according to the issued signals.

15. A method according to any one of the preceding claims, wherein the charging device is an at least partially electric vehicle.

16. A charger apparatus for electrically charging a chargeable device, comprising:

at least one connector suitable for at least supplying electric charging power to said chargeable device;

a source of electric charging power; and

a processing utility configured to:

electrically connect and disconnect between said source of electric charging power and said at least one connector; and

selectively perform at least one charging session by a plurality of timely separated charging cycles, depending on power management conditions or instructions.

17. A charger apparatus according to claim 16, further comprising a communication module for communicatively linking said charger apparatus with the electric power supply network.

18. A charger apparatus according to claim 16 or 17, wherein the processor utility is configured to manage the timely separated charging cycles by the issue of signals to the chargeable device indicating termination of a charging cycle.

19. A charger according to claim 18, wherein the signals indicating termination of the charging cycle comprises at least one of the following signals:

5% duty cycle pilot;

100% duty cycle pilot;

0% duty cycle pilot; and

0 Volts pilot signal.

20. A charger apparatus according to claim 18 or 19, wherein the processor utility is configured to issue signals to the chargeable device indicating commencement of a charging cycle.

21. A charger apparatus according to claim 20, wherein the processor utility is configured to encode a permissible level of electric charging consumption power in the signals indicating commencement of a charging cycle.

22. A charger apparatus according to any one of claims 16 to 21, further comprising an input device configured to receive data from at least one of the following: the chargeable device; a user of said chargeable device; an identifying token carried by said user or by said chargeable device.

23. A charger apparatus according to any one of claims 16 to 22, wherein the processor utility is configured to determine a suitable charging session management signaling scheme, said suitable charging session management signaling scheme defining signal patterns supported by the chargeable device and suitable for indicating the chargeable device at least termination of a charging cycle, and wherein said processor utility is configured to determine said suitable charging session management signaling scheme based at least in part on data received from the communication module or from the input device.

24. A charger apparatus according to any one of claims 16 to 23, wherein the processor utility is configured to determine a suitable charging session management signaling scheme, said suitable charging session management signaling scheme defines signal patterns supported by the chargeable device and suitable for indicating to the chargeable device at least the termination of a charging cycle, and wherein the processor utility is configured to determine the suitable charging session management signaling scheme after starting a charging session by successively issuing charging cycle termination signal patterns, each of said charging cycle termination signal patterns belonging to a respective charging session management signaling scheme, and choosing the respective charging session management signaling scheme upon receipt of a responsive signal pattern from the chargeable device or upon sensing that the chargeable device stopped consumption of the electrical charging power.

25. A charger apparatus according to any one of claims 16 to 24, wherein the chargeable device is an at least partially electric vehicle, and wherein the processor utility is configured to:

receive data indicative of electric power supply regulating instructions; and

issue signals to the chargeable device indicative of said electric power supply regulating instructions, thereby allowing the chargeable device to regulate the consumption of electric charging power according to the issued signals.

26. An electric charge spot network, comprising

a plurality of charge spots connectable to charging devices and configured to controllably supply said charging devices electric charging power and communicate a plurality of signals therewith, said charge spots being configured to receive data indicative of power management conditions or instructions, and issue, based on said power management conditions or instructions, signals indicative of commencement or termination of charging cycles, for regulating the supply of the electric charging power based on said data.

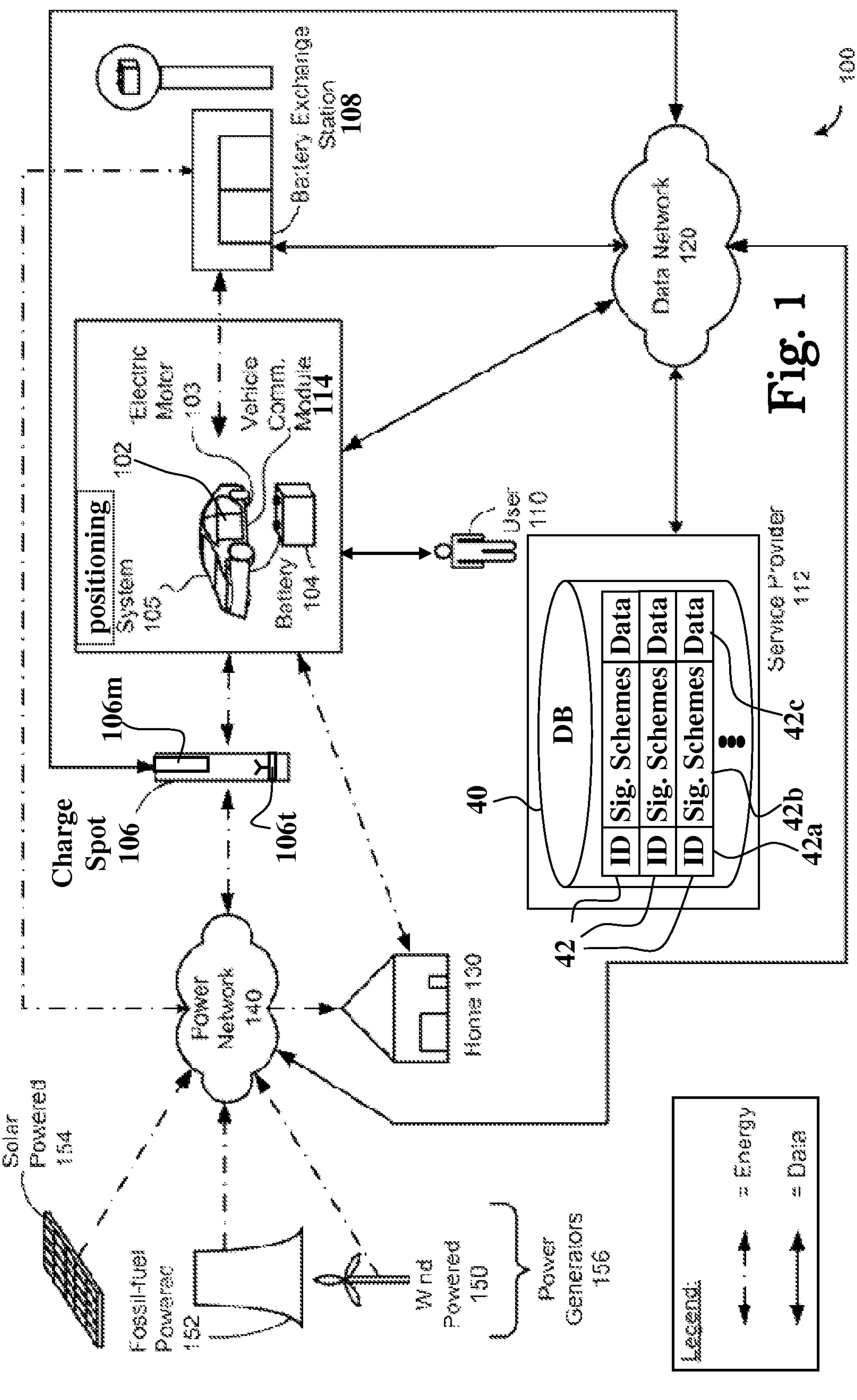

Battery Exchange Station
108
Data Network
120
100
positioning
System
105
102
Electric Motor
103
Vehicle Comm. Module
114
Battery
104
User
110
Service Provider
112
DB
40
ID
Sig. Schemes
Data
42
42a
42b
42c
Charge Spot
106
106m
106t
Power Network
140
Home 130
Solar Powered
154
Fossil-fuel Powered
152
Wind Powered
150
Power Generators
156
Legend:
= Energy
= Data

Fig. 1

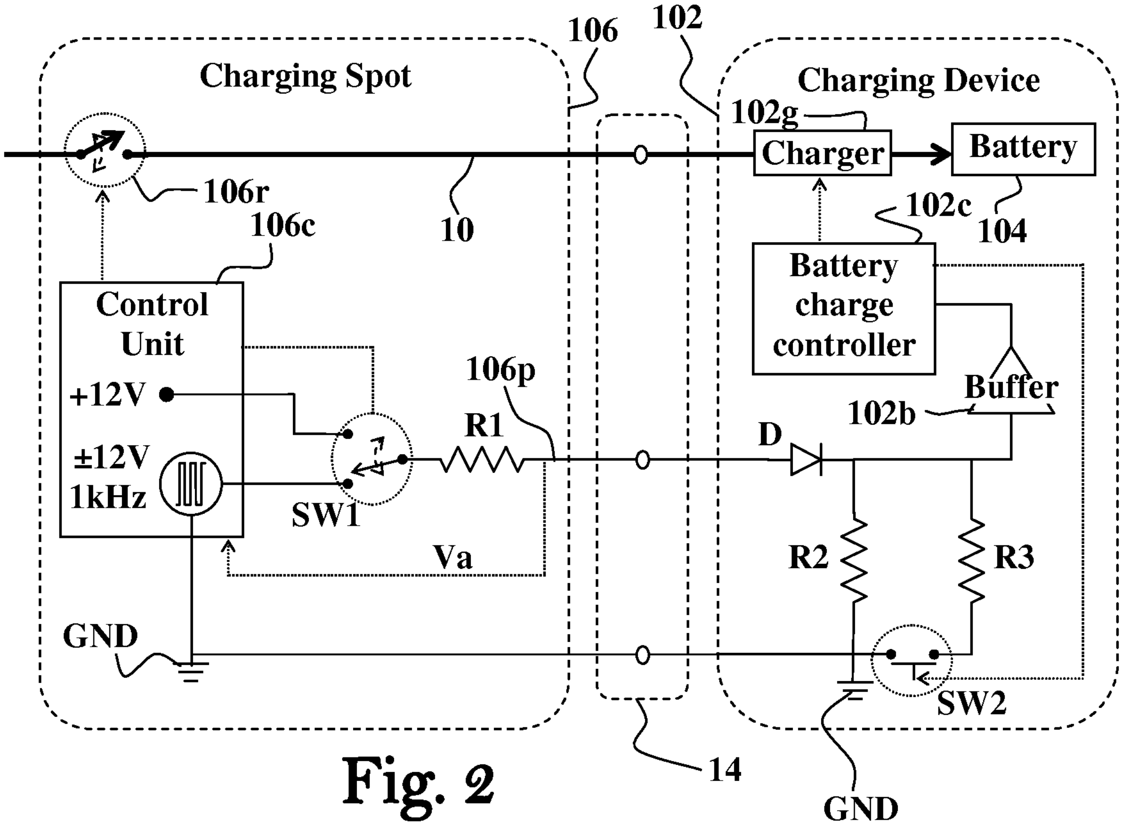

106
102
Charging Spot
Charging Device
102g
Charger
Battery
106r
10
102c
104
106c
Battery charge controller
Control Unit
+12V
±12V 1kHz
106p
R1
SW1
Va
Buffer
102b
D
R2
R3
GND
SW2
14
GND

Fig. 2

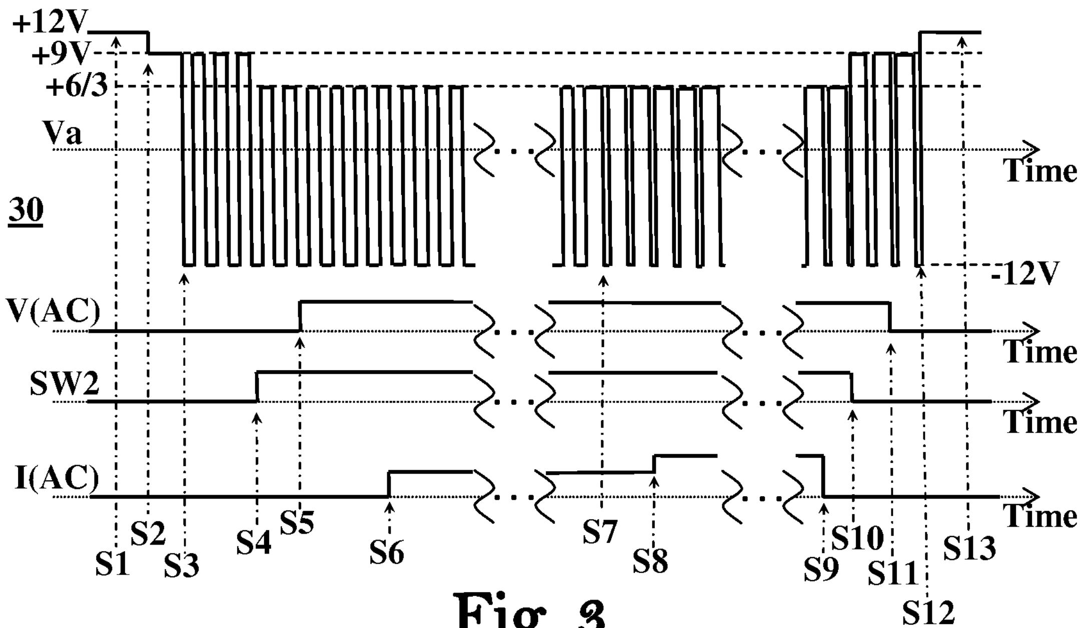

+12V
+9V
+6/3
Va
30
Time
-12V
V(AC)
SW2
I(AC)
S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13

Fig. 3

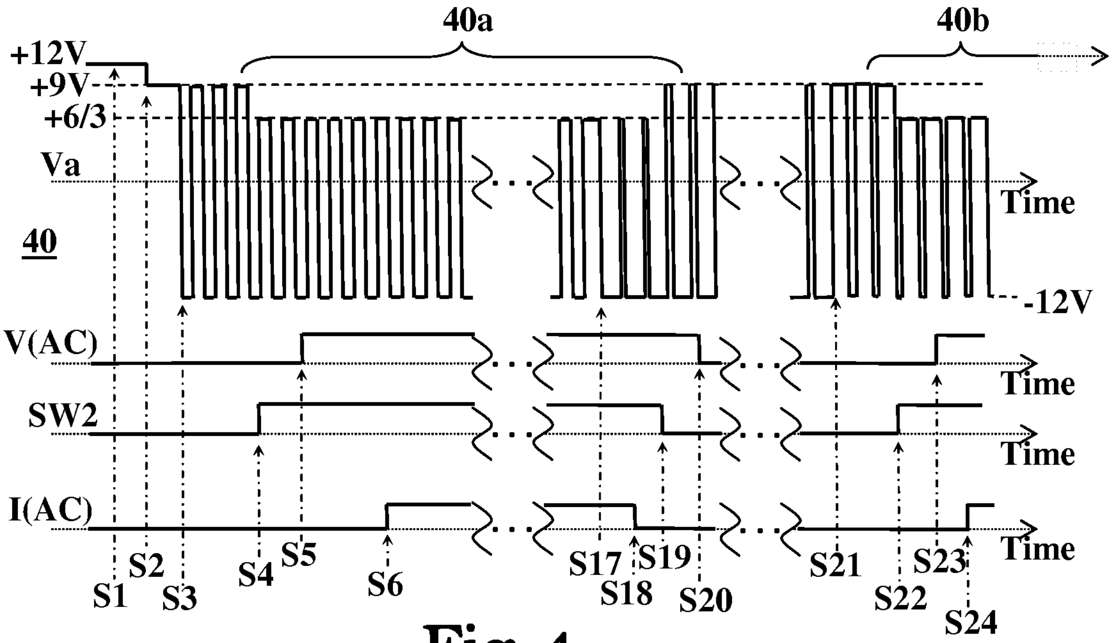

40a
40b
+12V
+9V
+6/3
Va
40
Time
-12V
V(AC)
Time
SW2
Time
I(AC)
Time
S1
S2
S3
S4
S5
S6
S17
S18
S19
S20
S21
S22
S23
S24

Fig. 4

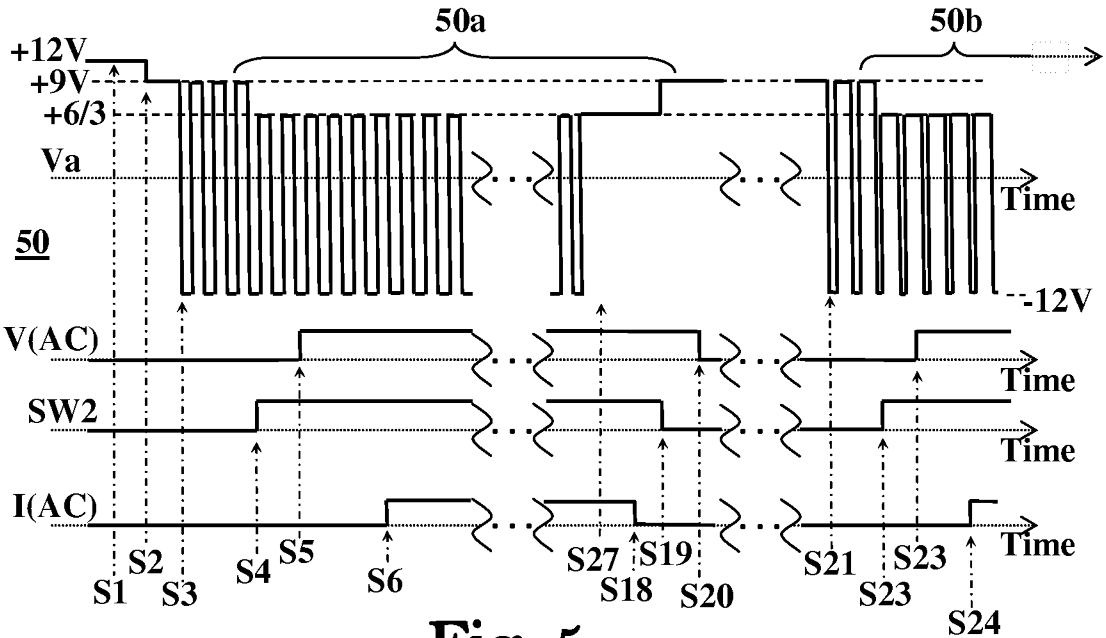
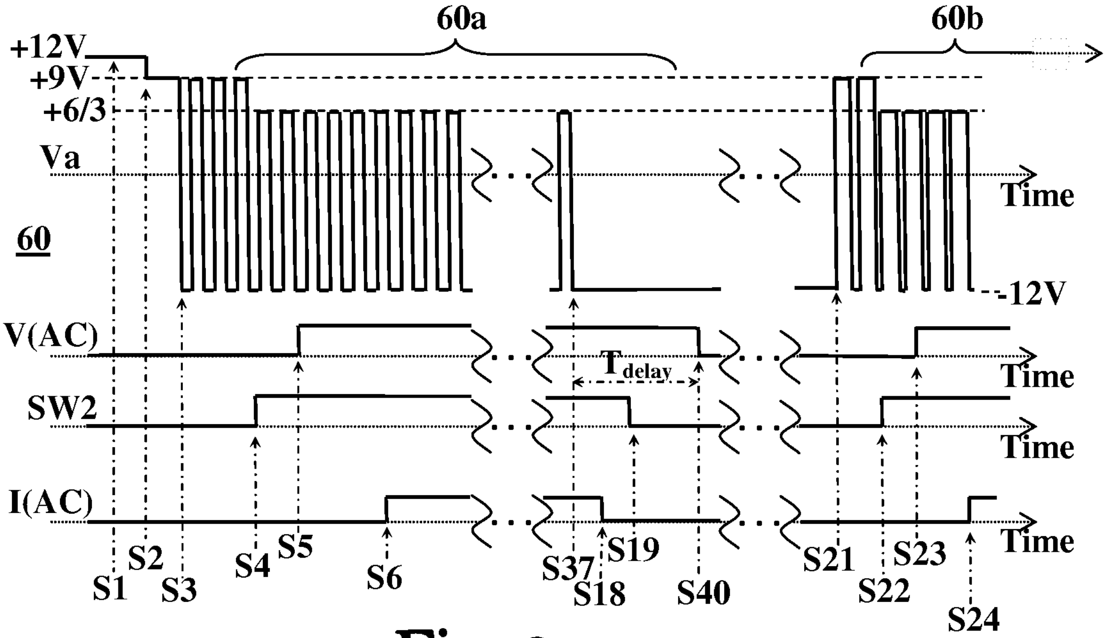
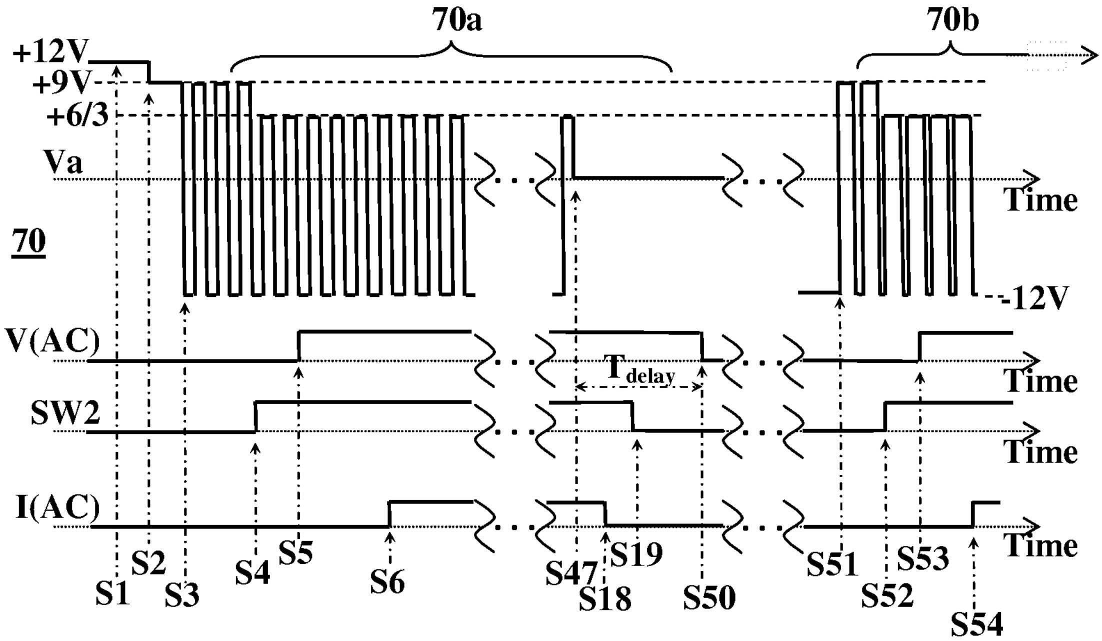

50a
50b
+12V
+9V
+6/3
Va
50
Time
-12V
V(AC)
Time
SW2
Time
I(AC)
Time
S1
S2
S3
S4
S5
S6
S27
S18
S19
S20
S21
S23
S23
S24

Fig. 5



60a
60b
+12V
+9V
+6/3
Va
Time
60
-12V
V(AC)
Time
Tdelay
SW2
Time
I(AC)
Time
S1
S2
S3
S4
S5
S6
S37
S18
S19
S40
S21
S22
S23
S24

Fig. 6



70a
70b
+12V
+9V
+6/3
Va
Time
70
-12V
V(AC)
Time
Tdelay
SW2
Time
I(AC)
Time
S1
S2
S3
S4
S5
S6
S47
S18
S19
S50
S51
S52
S53
S54

Fig. 7

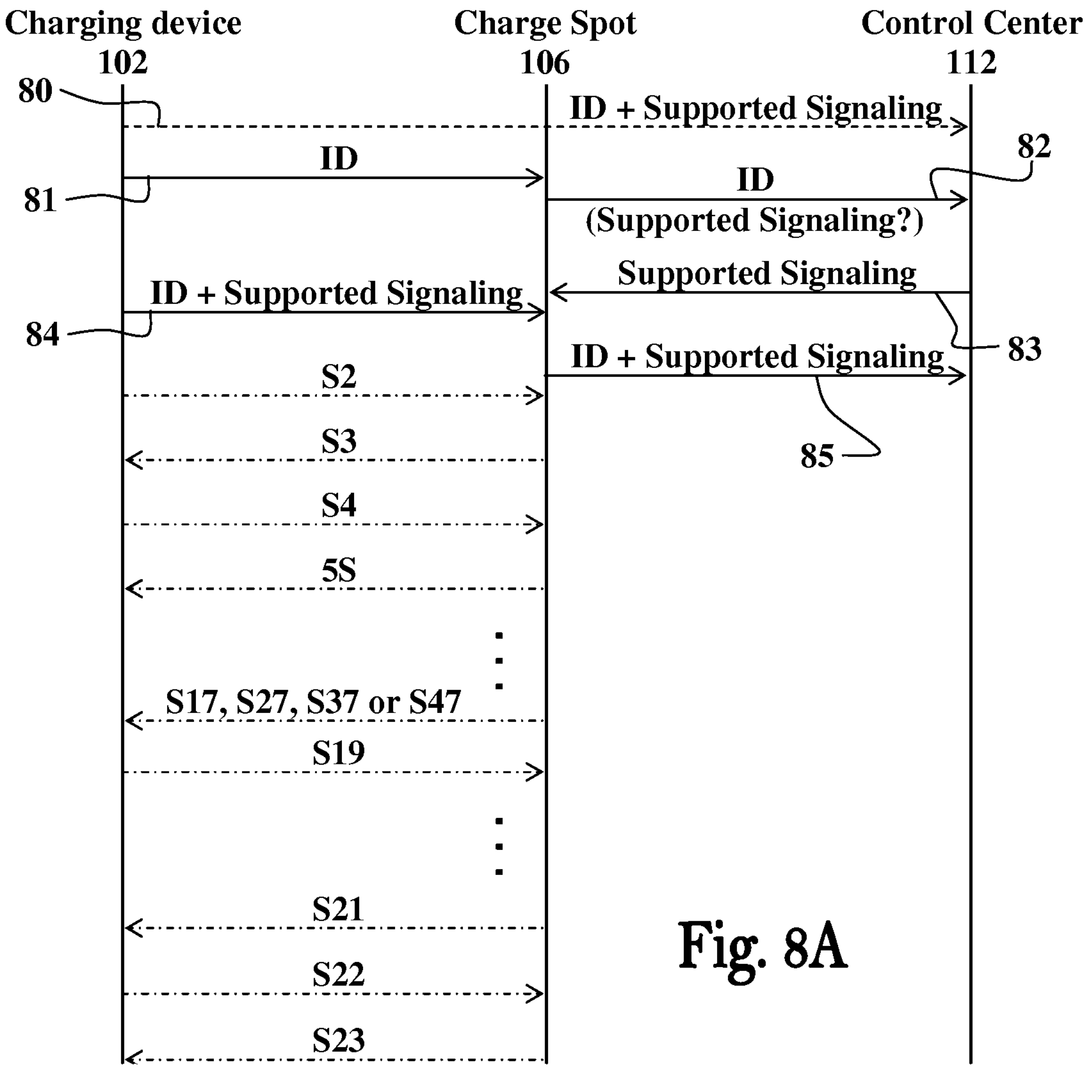

Charging device
102
Charge Spot
106
Control Center
112
80
ID + Supported Signaling
82
ID
81
ID
(Supported Signaling?)
Supported Signaling
ID + Supported Signaling
84
83
ID + Supported Signaling
S2
85
S3
S4
5S
S17, S27, S37 or S47
S19
S21
S22
S23

Fig. 8A

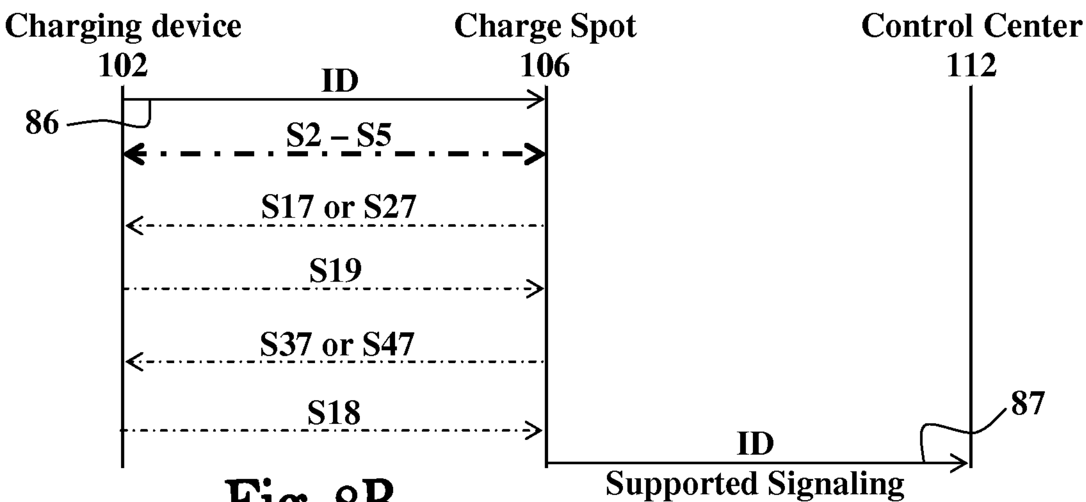

Charging device
102
Charge Spot
106
Control Center
112
ID
86
S2 – S5
S17 or S27
S19
S37 or S47
87
S18
ID
Supported Signaling

Fig. 8B

INTERNATIONAL SEARCH REPORT

International application No
PCT/IL2013/050109

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60L11/18 H02J3/14 H02J3/32
ADD.

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)
B60L H02J

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010/141205 Al (TYLER RICHARD M [US] ET AL) 10 June 2010 (2010-06-10) paragraphs [0039] - [0078]; figures 1-10 -----	1-26
X	US 2012/032636 Al (BIANCO JAMES S [US]) 9 February 2012 (2012-02-09) paragraphs [0043] - [0055]; figure 12 -----	1, 16,26
A	US 2011/245987 Al (PRATT RICHARD M [US] ET AL) 6 October 2011 (2011-10-06) the whole document -----	1-26
A	US 2011/109266 Al (ROSSI JOHN [US]) 12 May 2011 (2011-05-12) the whole document -----	1-26
	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" documentwhich may throw doubts on priority claim(s) orwhich is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 June 2013	10/07/2013

Name and mailing address of the ISA/
European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer
Hunckler, Jose

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2011/282513 AI (SON DONG MIN [KR] ET AL) 17 November 2011 (2011-11-17) the whol e document -----	1-26
A	US 2010/134067 AI (BAXTER DAVID [US] ET AL) 3 June 2010 (2010-06-03) the whol e document -----	1-26

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IL2013/050109

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2010141205 AI	10-06-2010	NONE	
US 2012032636 AI	09-02-2012	NONE	
US 2011245987 AI	06-10-2011	CA 2793989 AI	13-10-2011
		CN 102934319 A	13-02-2013
		EP 2556578 A2	13-02-2013
		US 2011245987 AI	06-10-2011
		US 2012200160 AI	09-08-2012
		WO 2011127047 A2	13-10-2011
US 2011109266 AI	12-05-2011	EP 2531369 A2	12-12-2012
		JP 2013519354 A	23-05-2013
		US 2011109266 AI	12-05-2011
		US 2013141043 AI	06-06-2013
		WO 2011097142 A2	11-08-2011
US 2011282513 AI	17-11-2011	CN 102244401 A	16-11-2011
		JP 2011244682 A	01-12-2011
		KR 20110125542 A	21-11-2011
		US 2011282513 AI	17-11-2011
US 2010134067 AI	03-06-2010	US 2010134067 AI	03-06-2010
		US 2011316482 AI	29-12-2011