

US 9,509,171 B2

Method and apparatus for optimizing standby power consumption and providing user indications in WPC based wireless charging system

Exemplary of: Wireless Charging Technology

US009509171B2

(12) **United States Patent**
Landgren et al.

(10) **Patent No.:** US 9,509,171 B2
(45) **Date of Patent:** Nov. 29, 2016

(54) **METHOD AND APPARATUS FOR OPTIMIZING STANDBY POWER CONSUMPTION AND PROVIDING USER INDICATIONS IN WPC BASED WIRELESS CHARGING SYSTEM**

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(*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 111 days.

(21) **Appl. No.:** 14/362,912
(22) **PCT Filed:** Dec. 15, 2011
(86) **PCT No.:** PCT/FI2011/051111
§ 371 (c)(1),
(2), (4) Date: Jun. 4, 2014

(87) **PCT Pub. No.:** WO2013/087971
PCT Pub. Date: Jun. 20, 2013

(65) **Prior Publication Data**
US 2014/0306657 A1 Oct. 16, 2014

(30) **Foreign Application Priority Data**
Dec. 14, 2011 (WO) PCT/FI2011/051105

(51) **Int. Cl.**
H02J 7/00 (2006.01)
H02J 7/02 (2016.01)
H02J 7/04 (2006.01)

(52) **U.S. Cl.**
CPC H02J 7/025 (2013.01); H02J 7/045 (2013.01)

(58) **Field of Classification Search**
CPC H02J 7/04; H02J 7/005; H02J 7/007; H02J 7/008; H02J 7/0025
USPC 320/108, 132, 137, 149
See application file for complete search history.

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(57) **ABSTRACT**
In accordance with an example embodiment of the present invention, a method for reducing standby power consumption of a battery of a wireless charging device comprises: monitoring a presence of the wireless charging device nearby a wireless charger transmitter (460); initiating a wireless charging when the presence of the wireless charging device is detected on the wireless charger transmitter (460) and sending a charging notification to an end user; sending a battery full message for notifying the end user when the wireless charging is complete and terminating the wireless charging; setting the wireless charging device to a standby mode and monitoring a ping signal from the wireless charger transmitter (460); entering a maintenance charging mode when the battery is below a recharging threshold without notifying the end user; and continuing the maintenance charging mode of the wireless charging device until the battery is full or the wireless charging device is removed from the wireless charger transmitter (460).

6 Claims, 5 Drawing Sheets

<https://patents.google.com/patent/US9509171>

1. An apparatus, comprising:

at least one processor; and

at least one memory including computer program code,

the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to:

initiate a wireless charging and send a charging notification to an end user;

send a battery full message for notifying the end user when a battery is charged to a full voltage by the wireless charging and terminating the wireless charging;

set the apparatus to a standby mode and monitor a ping signal from a wireless charger transmitter to detect whether the apparatus is removed from the wireless charger transmitter;

enter a maintenance charging mode without sending the charging notification to the end user, when a voltage of the battery drops from the full voltage to below a recharging threshold; and

continue the maintenance charging mode of the apparatus until the battery is charged to the full voltage or the apparatus is removed from the wireless charger transmitter.

US 9,509,171 B2 Claim 1

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continue the maintenance charging mode of the apparatus until the battery is charged to the full voltage or the apparatus is removed from the wireless charger transmitter.



Operating System	Android 6.0 Marshmallow
Display	5.1-inch 2560x1440 Super AMOLED
Processor	Quad-core Snapdragon 820 or Octa-core Samsung Exynos 8
Storage	32GB
Expandable	microSD up to 200GB
RAM	4GB
Rear Camera	12MP f/1.7 1.4-micron pixels OIS
Front Camera	5MP f/1.7
Connectivity	Wi-Fi 802.11 ac MIMO Bluetooth v4.2 LE ANT+, USB 2.0, NFC
Charging	Micro-USB Fast charging Qi wireless Powermat wireless

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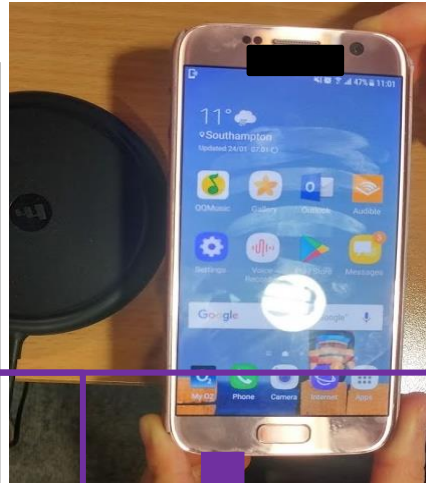
initiate a wireless charging and send a charging notification to an end user;

send a battery full message for notifying the end user when a battery is charged to a full voltage by the wireless charging and terminating the wireless charging;

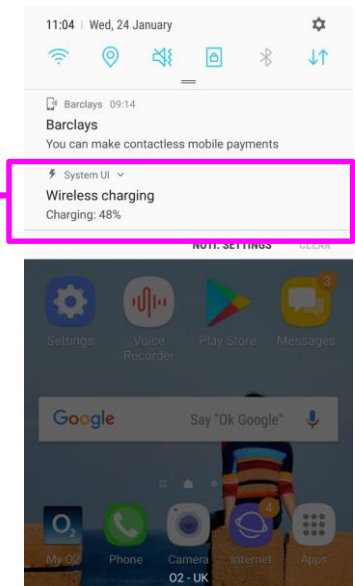
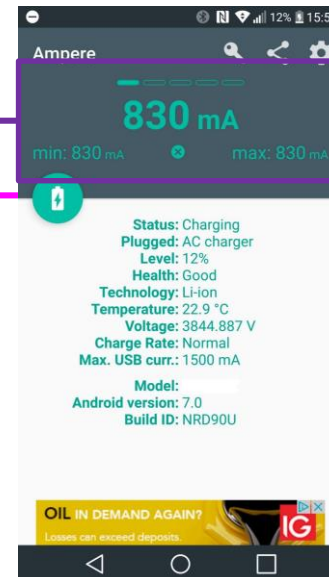
set the apparatus to a standby mode and monitor a ping signal from a wireless charger transmitter to detect whether the apparatus is removed from the wireless charger transmitter;

enter a maintenance charging mode without sending the charging notification to the end user, when a voltage of the battery drops from the full voltage to below a recharging threshold; and

continue the maintenance charging mode of the apparatus until the battery is charged to the full voltage or the apparatus is removed from the wireless charger transmitter.



Comment: Wireless charging is initiated by placing the device on the charging pad. This is indicated by a blue circle graphic on the screen, then a charging notification in the notification panel. Current to the battery is measured as 830mA



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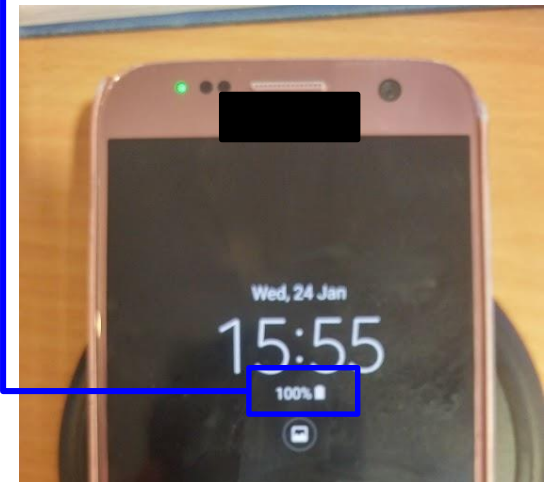
13.2 User interaction with a Mobile Device

A Mobile Device should indicate the following conditions to users:

- Successful reception of the Power Signal within 3 seconds after being placed on a Base Station.
- End of reception of the Power Signal.

Moreover, if the Power Receiver has transmitted an End Power Transfer Packet, the Power Receiver shall remain in the *power transfer* phase until the Power Transmitter removes the Power Signal. Furthermore, the Power Receiver should transmit additional End Power Transfer Packets if the Power Transmitter does not remove the Power Signal.⁷ For battery-charging applications, it is recommended that the Power Receiver sends an End Power Transfer Packet containing an End Power Transfer Code 0x01 on detecting that the battery is fully charged.

Comment: The Qi wireless charging standards stipulate that the device must indicate to the user when charging starts and stops, and that charging should be stopped when the phone detects that the battery is full. On our test device the notification indicates that the battery is charged to 100%.



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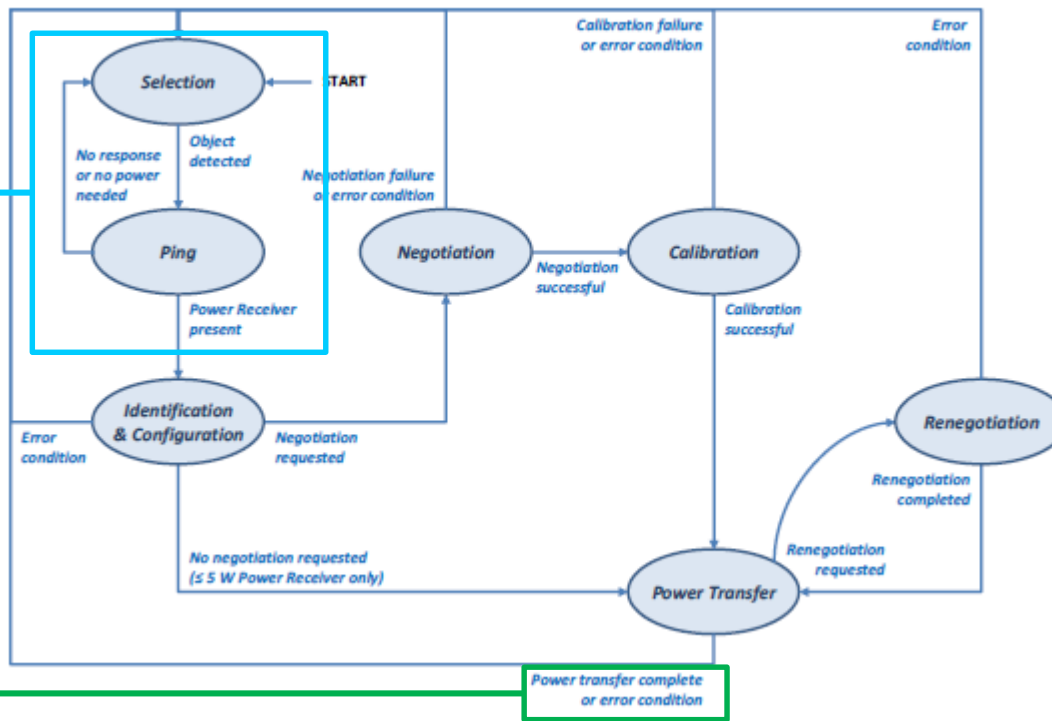
send a battery full message for notifying the end user when a battery is charged to a full voltage by the wireless charging and terminating the wireless charging;

set the apparatus to a standby mode and monitor a ping signal from a wireless charger transmitter to detect whether the apparatus is removed from the wireless charger transmitter;

enter a maintenance charging mode without sending the charging notification to the end user, when a voltage of the battery drops from the full voltage to below a recharging threshold; and

continue the maintenance charging mode of the apparatus until the battery is charged to the full voltage or the apparatus is removed from the wireless charger transmitter.

Figure 18. Power transfer phases—Extended Power Profile



Comment: Once the power transfer has been ended the charger enters the Ping mode, in which it repeatedly pings the mobile device. The device responds to each ping indicating that it doesn't require any power and the charger remains in the ping mode.

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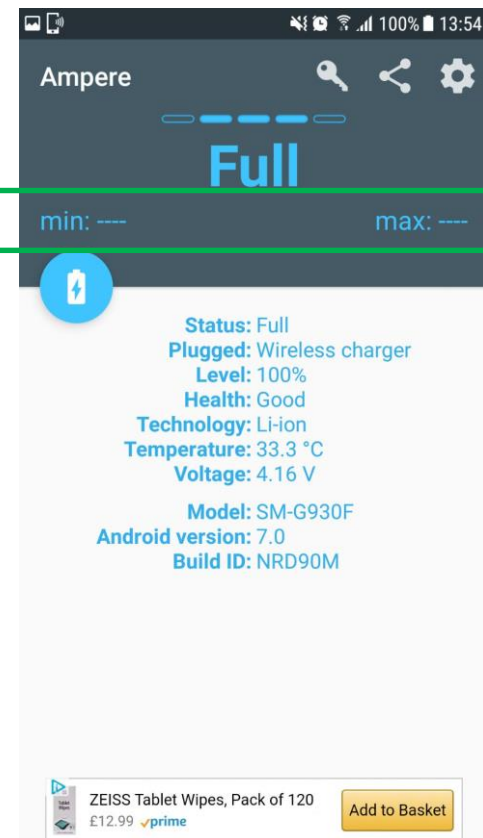
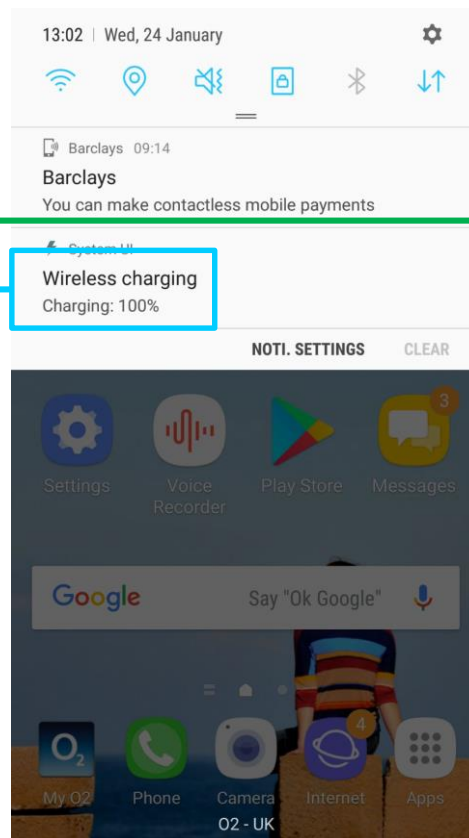
send a battery full message for notifying the end user when a battery is charged to a full voltage by the wireless charging and terminating the wireless charging;

set the apparatus to a standby mode and monitor a ping signal from a wireless charger transmitter to detect whether the apparatus is removed from the wireless charger transmitter;

enter a maintenance charging mode without sending the charging notification to the end user, when a voltage of the battery drops from the full voltage to below a recharging threshold; and

continue the maintenance charging mode of the apparatus until the battery is charged to the full voltage or the apparatus is removed from the wireless charger transmitter.

Comment: The user notification indicates that the device is still detecting that is connected to the wireless charger. Although the notification says “Wireless Charging”, the right hand screen shot indicates that no current is actually being received.



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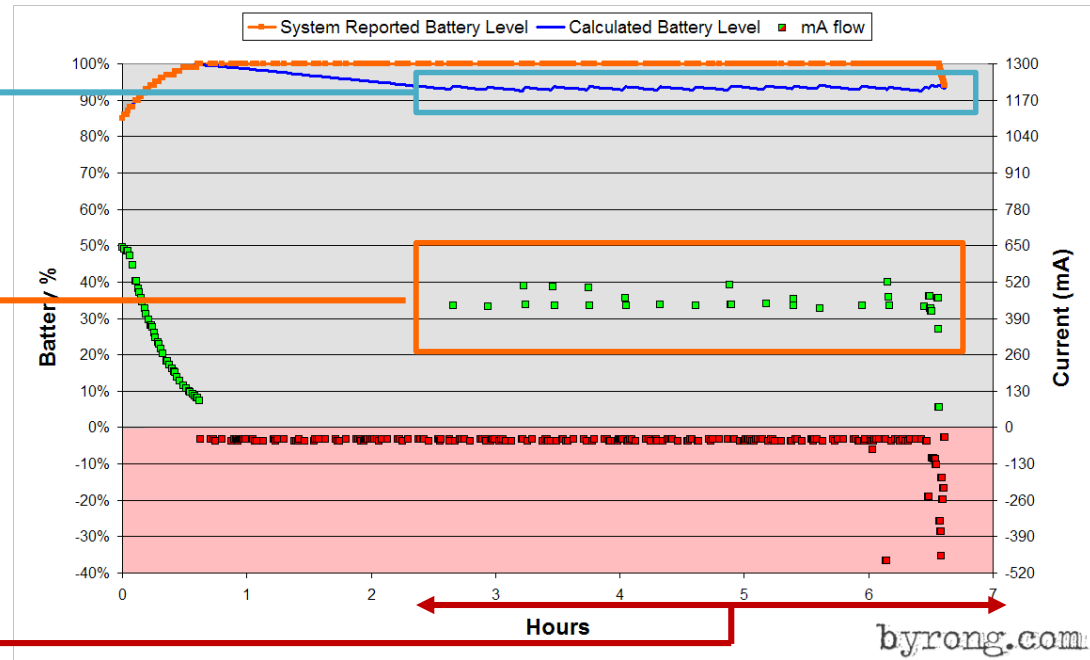
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and continue the maintenance charging mode of the apparatus until the battery is charged to the full voltage or the apparatus is removed from the wireless charger transmitter.



When lithium-ion batteries must be left in the charger for operational readiness, some chargers apply a brief topping charge to compensate for the small self-discharge the battery and its protective circuit consume. The charger may kick in when the open circuit voltage drops to 4.05V/cell and turn off again at 4.20V/cell. Chargers made for operational readiness, or standby mode, often let the battery voltage drop to 4.00V/cell and recharge to only 4.05V/cell instead of the full 4.20V/cell. This reduces voltage-related stress and prolongs battery life.

Comment: The above testing shows that once a device battery is charged it stops receiving charge until the battery voltage falls to a certain level then receives a small amount of charge to return it to above that level. The user is not aware of this charging process as the battery the battery level is indicated at 100% the whole time.

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NOTE If the Power Receiver remains in the power transfer phase, a situation could occur in which charging and power transfer indicators on the Mobile Device and Base Station, respectively, provide conflicting messages to the user. For example, the Mobile Device indicates that the battery is not charging but the Base Station indicates that power transfer is in progress. Note that the Power Receiver can restart power transfer after receiving a next Digital Ping from the Power Transmitter and the Power Receiver detecting that the charging level of the battery has dropped below some threshold.

At any time a user can remove a Mobile Device that is receiving power. The Power Transmitter can recognize such an event from a time-out in the communications from the Power Receiver, or from a violation of the Power Transfer Contract. As a result, the Power Transmitter aborts the power transfer and the system reverts to the selection phase.