

Patent Points

NOW STARTING MY 29TH YEAR...

Electric Vehicle (EV) Patents

After writing several patents related to Electric Vehicles (EVs), I purchased an EV this year to gain better insight on the technologies used by EVs and the particular challenges faced by drivers.

The battery itself in my EV weights about 1,000 pounds. Recycling these huge batteries when large numbers of EVs are retired or have their batteries replaced in the future is a particular technical challenge. Some of these batteries may still be useful for other applications, even though they not longer meet the specifications for the EV. For example, some retired batteries may be used for utility energy storage where bulk and inefficiency are less important than cost.

One of my clients has been developing battery screening methods that can allow old batteries to be tested for their State of Health (SOH). Traditionally each retired battery is fully charged and then fully drained to determine how much charge the battery can currently hold. However it is very slow to fully charge and discharge each battery. Instead, the inventors discharge the battery over a very small range, such as 0.1

volt ! This greatly reduces test time. The test results are compared to a calibration curve to estimate the battery's SOH.

The calibration curve model is obtained by Artificial Intelligence (AI) modeling of Open-Circuit Voltage (OCV) and State-of-Charge (SOC) datapoints from fully charging and discharging a modeling-test group of used batteries. Only OCV values within a target region having a low first derivative of SOC as a function of OCV are modeled, and the range of modeled OCV values are within this target region

Another patent is for an on-board EV charger (page 3). As a new EV owner, charging can be confusing due to the wide variety of chargers. For example, a home charger may only provide 2-7 kW using single-phase AC, while a faster charger at work may use 3-phase AC, and a fast charger on the highway may provide DC current at 150 kW.

Some EVs can send power back to the grid (V2G) or home (V2H). The inventors also support DC charging directly from solar panels without conversion losses to AC.

The inventors' on-board charger is replaced with a Smart Power Hub.

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2 Battery SOH Patent

3 EV Smart Power Hub

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US011422199B1

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

(10) **Patent No.:** **US 11,422,199 B1**
(45) **Date of Patent:** **Aug. 23, 2022**

- (54) **STATE OF HEALTH EVALUATION OF RETIRED LITHIUM-ION BATTERIES AND BATTERY MODULES**
- (71) Applicant: **Hong Kong Applied Science and Technology Research Institute Company, Limited**, Hong Kong (HK)
- (72) Inventors: **Minjie Xu**, Hong Kong (HK); **Yaofeng Sun**, Hong Kong (HK)
- (73) Assignee: **Hong Kong Applied Science and Technology Research Institute Company Limited**, Hong Kong (HK)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(22) Filed: **Jun. 17, 2021**

- (51) **Int. Cl.**
G01R 31/392 (2019.01)
G01R 31/36 (2020.01)
G01R 31/374 (2019.01)
H01M 10/613 (2014.01)
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- (52) **U.S. Cl.**
 CPC **G01R 31/392** (2019.01); **G01R 31/367** (2019.01); **G01R 31/3648** (2013.01); **G01R 31/374** (2019.01); **H01M 10/54** (2013.01); **H01M 10/613** (2015.04); **H02J 7/005** (2020.01)

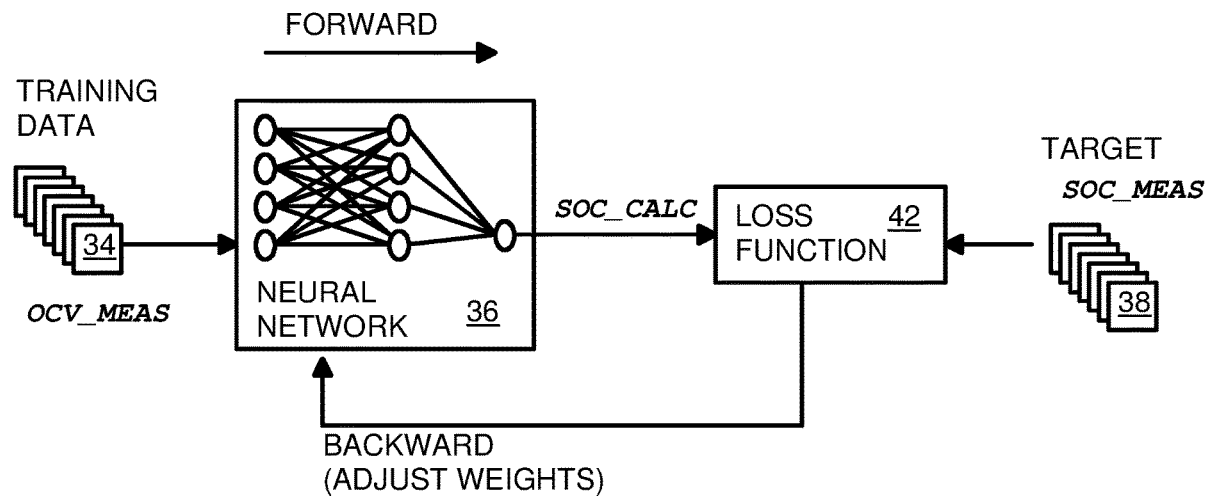
- (58) **Field of Classification Search**
 CPC G01R 31/392; G01R 31/3648; G01R 31/367; G01R 31/374; H01M 10/54; H01M 10/613; H02J 7/005
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 See application file for complete search history.

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(57) **ABSTRACT**
 A used battery is discharged for a short time from a first Open Circuit Voltage (OCV1) to a second OCV2 and the discharge current ΔQ measured. OCV1 is input to a calibration curve model to obtain a first modeled State of Charge (SOC1) value, and OCV2 is input to the calibration curve model to obtain a second modeled SOC2 value. The State of Health (SOH) is calculated as $\Delta Q/[Q_{new} \times (SOC1 - SOC2)]$, where Q_{new} is the battery capacity when new. The used battery is sorted for reuse or disposal based on the SOH value. The calibration curve model is obtained by Artificial Intelligence (AI) modeling of OCV, SOC datapoints from fully charging and discharging used batteries. Only OCV values within a target region having a low first derivative of SOC as a function of OCV are modeled, and OCV1 and OCV2 are within this target region.

20 Claims, 12 Drawing Sheets





US011407322B2

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

(10) **Patent No.:** **US 11,407,322 B2**
(45) **Date of Patent:** **Aug. 9, 2022**

- (54) **SMART POWER HUB**
- (71) Applicant: **Hong Kong Applied Science and Technology Research Institute Company, Limited**, Hong Kong (HK)
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- (73) Assignee: **Hong Kong Applied Science and Technology Research Institute Company, Limited**, Hong Kong (HK)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 490 days.
- (21) Appl. No.: **16/561,274**
- (22) Filed: **Sep. 5, 2019**
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B60L 53/51 (2019.01)
B60L 53/14 (2019.01)
- (52) **U.S. Cl.**
CPC **B60L 53/22** (2019.02); **B60L 53/14** (2019.02); **B60L 53/51** (2019.02);
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- (58) **Field of Classification Search**
CPC B60L 53/14; B60L 53/22; B60L 53/51;
B60L 2210/46; Y02T 10/70; Y02T 10/72;
Y02T 10/7072; Y02T 90/12; Y02T 90/14
See application file for complete search history.

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Primary Examiner — Richard Isla

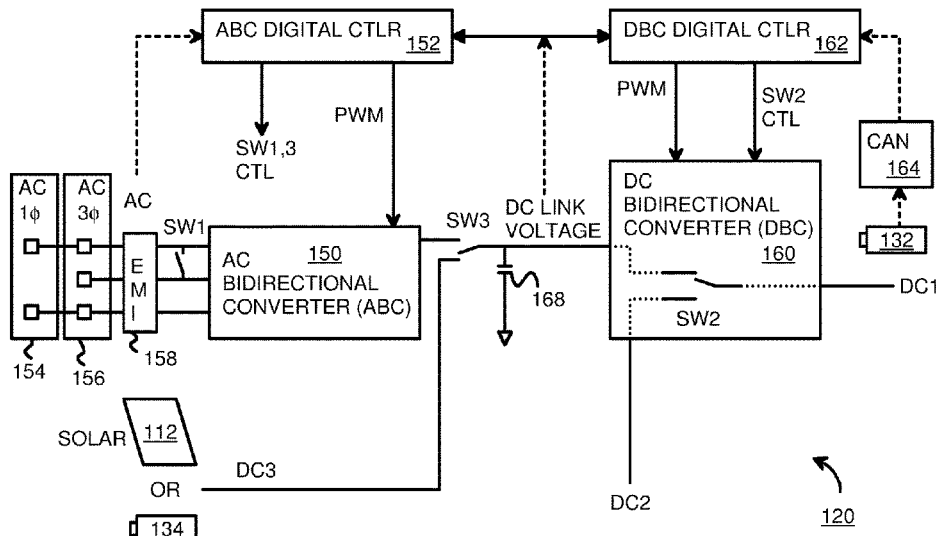
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(57) **ABSTRACT**

A smart power hub has an AC port, a first DC port to a car battery, a second DC port to DC devices such as car instruments, and a third DC port to solar panels or another smart power hub. An AC bi-directional converter has six transistors in a B6 configuration to convert three-phase AC, acting as an interleaved totem-pole Power-Factor-Corrector for one-phase AC. A switch connects the DC bi-directional converter with either the AC bi-directional converter or the solar panels on the third DC port. A link capacitor has a DC link voltage that rises during battery charging. A DC bi-directional converter has a transformer, a primary bridge connected to the DC link voltage, and a secondary bridge of transistors connected to the first DC port. Auxiliary windings in the transformer drive a rectifier to the second DC port to power on-board DC devices. Solar DC charges the battery without AC conversion.

15 Claims, 27 Drawing Sheets



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579 Patents Issued

After 28 years of writing patents as a full-time Patent Agent, 579 applications that I've written have now issued as patents. Congratulations inventors!

You can view the 579 issued patents I've written at:

www.gpatent.com

Rates Set for 2023

My hourly rate for 2023 will be \$390 per hour, billed in quarter-hour increments. Fixed-price quotes are available for patent applications to facilitate budgeting and avoid expensive surprises.

Prosecution work such as amendments and other paperwork is billed at the hourly rate. Litigation-support work is billed at a higher rate. Patent searches are billed at a flat \$500 for U.S. abstract searches. Patents can be viewed on-line.

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Address Correction Requested