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NEOVOLT: AN ESP32-BASED PROTOTYPE FOR BATTERY VOLTAGE AND CURRENT MONITORING TOWARD EV BATTERY HEALTH ESTIMATION

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2. ABSTRACT

Battery health matters a great deal in electric vehicles (EVs) because it affects safety, driving range, and when a pack needs servicing. This paper describes NEOVOLT, a small college-level prototype that reads battery voltage and current with an ESP32 microcontroller and sets out a method for estimating State of Health (SOH) as a percentage. The ESP32 samples a voltage-sensor module, converts the raw ADC count into an estimated terminal voltage, and prints the result on a serial monitor. A current sensor is included so that charge can be integrated over time once a suitable load and a calibrated sensor are available. So far the system has been tried only on a small 9 V battery, not an EV traction pack, and three preliminary voltage comparisons against a multimeter are reported. In those readings the ESP32 value was 0.06 to 0.07 V below the multimeter reference. The work therefore presents a measurement workflow and a proposed capacity-based SOH calculation; it does not claim validated SOH prediction for EV batteries.

3. KEYWORDS: Electric vehicle; Battery monitoring; State of Health; ESP32; Voltage sensing; Current sensing; Capacity estimation.

4. INTRODUCTION

Rechargeable batteries sit at the heart of every electric vehicle. Over time their usable capacity and internal condition change with use, charging habits, temperature, and age. Keeping an eye on these changes helps owners and technicians decide when a battery needs inspection or replacement. In a real EV this job is handled by a battery-management system that combines several measurements with battery-specific models [2]. A bare voltage reading cannot do the same job on its own.

NEOVOLT is a prototype that demonstrates the basic steps of sensing battery voltage with an ESP32 and presenting the result in an understandable form. A current sensor is part of the planned setup so that current can be recorded once a suitable test load and safe wiring are in place. Because a full EV battery pack is outside the scope of this project, the first demonstration uses a small 9 V battery. A simple display of voltage does not tell us how much usable capacity remains or how far the battery has aged, so any percentage shown must not be called a measured SOH unless it has been compared with a proper reference capacity under controlled conditions.

The objectives of the study are: (i) to read battery voltage through a sensor module and process the analogue signal on the ESP32; (ii) to provide a basis for current measurement; (iii) to show the calculated output clearly; and (iv) to state honestly what the small-battery demonstration can and cannot show, and to list the measurements needed for future EV-battery testing. The main contribution is a simple embedded measurement prototype together with a documented way of reporting its readings. Cell balancing, a full EV battery-management system, machine-learning-based life prediction, and validation on a commercial traction battery are outside the present scope. The remainder of the paper is organised as follows. Section 4 also gives background and related work, Section 5 describes the architecture and methods, Section 6 reports and discusses the preliminary results and limitations, and Section 7 concludes.

4.1 Background and Related Work

State of Charge and State of Health. Battery monitoring usually separates State of Charge (SOC) from State of Health (SOH). SOC describes how much charge is left relative to what the battery can hold in its present condition. SOH compares the present condition with a defined reference, most often usable capacity or internal resistance [3], [4]. The exact definition depends on the chemistry, the manufacturer, and the application. Estimates based on voltage alone are easily disturbed by load, rest time, temperature, and the shape of the discharge curve.

Capacity-based estimation. Capacity-based SOH estimation needs a reference capacity and a usable capacity measured under a stated test procedure [5]. Current integration, commonly called coulomb counting, estimates the charge transferred over time, but sensor offset, sampling error, and an uncertain starting point can all add up to a growing error [3]. For this reason, voltage and current readings should be calibrated and interpreted with a battery-specific method before any SOH figure is treated as accurate. The present prototype follows these ideas only at a demonstration level and makes no claim of matching the performance of published estimation methods, which are surveyed in [4] and [5].

5. MATERIALS AND METHODS

5.1 Architecture Overview

The signal path starts at the battery terminals. A voltage-sensing module scales the battery voltage down to a range that the ESP32 analogue input can accept. The ESP32 samples this signal with its analogue-to-digital converter (ADC), turns the raw count into a voltage estimate using the configured scaling factor, and runs the programmed calculation [1]. The current sensor is wired to a separate analogue input, chosen to suit the sensor's output type and wiring needs. Results go to the serial monitor for now and could drive a dedicated display later (Fig. 1).

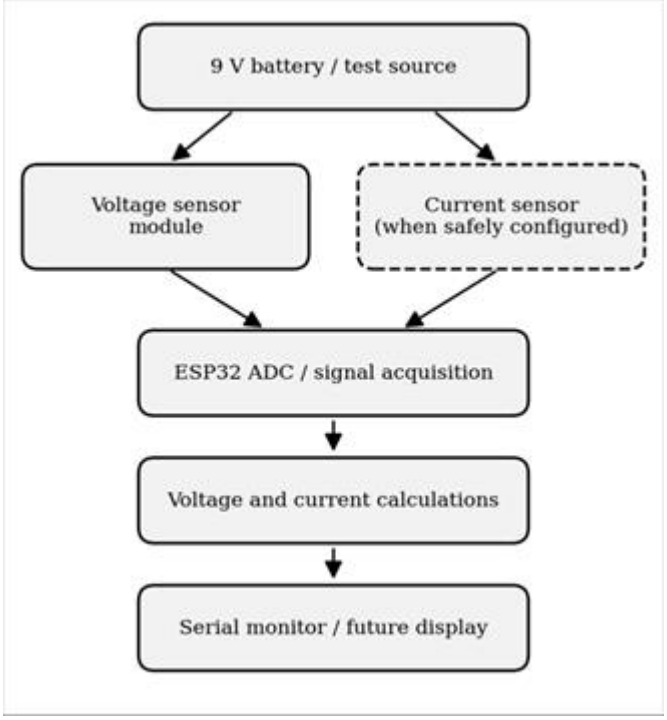


Fig. 1. Conceptual architecture of the NEOVOLT prototype. The current-sensing branch (dashed) needs a suitable test circuit and has not yet been validated.

5.2 Hardware Components

Table 1 lists the parts used or planned for the prototype.

Table 1. Hardware components of the NEOVOLT prototype.

Component	Purpose	Implementation note
ESP32 development board	Reads sensor outputs and performs calculations.	ADC scaling and pin assignments must match the actual board and code.
Voltage-sensing module	Scales battery voltage for measurement.	The module ratio is confirmed and calibrated against a multimeter.
Current-sensing module	Measures current through a suitable test path.	Sensor type, current range, output type, and wiring must be confirmed.
HW 9 V battery	Small demonstration source.	Not equivalent to an EV traction battery; not used to validate EV SOH.
Test load and connecting wires	Provide a controlled current path if current testing is performed.	Use a suitably rated load and avoid short circuits.
Laptop and USB connection	Uploads firmware and shows serial output.	Serves as the prototype display through the serial monitor.

5.3 Voltage Measurement

For a typical 12-bit ESP32 ADC setup, the raw reading runs from 0 to 4095. The actual conversion from count to ADC voltage depends on the board, the attenuation setting, the reference behaviour, and calibration [1]. The basic software relationship is

$$V_{ADC} \approx (ADC_{raw} / 4095) \times V_{FS} \quad (1)$$

$$V_{battery} \approx V_{ADC} \times K_{sensor} \quad (2)$$

where V_{ADC} is the voltage at the ADC input, V_{FS} is the full-scale voltage configured in the code, and K_{sensor} is the calibrated scaling factor of the voltage sensor. These expressions stay approximate until calibration is done, and the sensor output must always stay inside the ESP32 input limits.

5.4 Current and Capacity Estimation

Current can only be measured when the sensor is wired as its datasheet describes and current actually flows through the intended path. When current is sampled over time, the transferred charge can be approximated by a simple sum:

$$Q_{Ah} \approx (1/3600) \Sigma I_k \Delta t_k \quad (3)$$

Here I_k is the current in amperes and Δt_k is the sample interval in seconds. The sign convention has to be defined and the current sensor calibrated. Capacity estimation also needs a defined discharge test with a cutoff condition. A 9 V zinc-carbon battery is not rechargeable and must not be recharged or discharged in an uncontrolled way.

5.5 State of Health Calculation

A capacity-based SOH estimate is the ratio of the measured usable capacity to a suitable reference capacity:

$$SOH\ (\%) = (Q_{measured} / Q_{reference}) \times 100 \quad (4)$$

This is the proposed method for a future controlled test, not a result established by the current demonstration. The reference capacity has to belong to the same battery model and test conditions, and the formula must not be applied to a single voltage reading as if voltage were measured capacity. Until a reference capacity and a validated test exist, any percentage shown on the display should be labelled a demonstration estimate.

5.6 Prototype Software Flow

The firmware starts serial communication and the ADC configuration, reads the voltage sensor, converts the raw reading with the configured scaling factor, and prints the voltage. If the current sensor is connected and calibrated, the program can also read current and accumulate charge over the elapsed time. A percentage output should be enabled only when a defensible reference-capacity method is in place. The calibration constants, sensor model, sampling interval, and firmware version are recorded with every test.

6. RESULTS AND DISCUSSION

6.1 Voltage Comparison

Table 2 compares the ESP32-derived voltage with a multimeter reading for three measurements on the 9 V demonstration battery. The difference is the ESP32 value minus the multimeter reference, and the error is that difference as a percentage of the reference.

Table 2. ESP32-derived voltage versus multimeter reference. (9 V battery)

Test	Multimeter (V)	ESP32 (V)	Difference (V)	Error (%)
T1	8.72	8.65	−0.07	0.80
T2	8.70	8.64	−0.06	0.69
T3	8.52	8.45	−0.07	0.82

In all three tests the ESP32 reported a voltage 0.06 to 0.07 V lower than the multimeter, which is roughly 0.7 to 0.8% of the reference. Because the gap is nearly constant, it looks systematic, most likely a scaling-factor or ADC-offset effect, and calibration should be able to reduce it. Three readings are too few to confirm this, so we treat it as a first observation and not as an accuracy figure. The readings also say nothing about SOH, since voltage alone cannot establish capacity.

6.2 Status of Result Metrics

Table 3 summarises which results exist so far and which are still pending.

Table 3. Status of result metrics.

Metric	Status
Voltage difference	Three preliminary readings (Table 2)
Current measurement	Pending; sensor and safe test circuit to be confirmed
Capacity estimate	Pending; needs a controlled discharge test
SOH percentage	Not validated in the current demonstration

6.3 Evaluation Procedure

We first inspect the wiring and confirm that the sensor output stays within the ESP32 input limits. Next, the battery terminal voltage is measured with a multimeter and compared with the software reading, and the reading is repeated to check consistency. Current testing is carried out only after the sensor model, its rated range, and a safe load circuit have been confirmed. The sampling interval and every calibration constant are recorded. Capacity and SOH evaluation need a proper test protocol and reference data, and cannot be concluded from the voltage comparison alone.

6.4 Limitations

The 9 V demonstration battery differs greatly from an EV traction battery in chemistry, configuration, voltage, capacity, and operating conditions. A single voltage reading depends on load and battery state and cannot show long-term degradation. Results may also be affected by ADC non-linearity, sensor tolerance, wiring, loose connections, and uncalibrated constants in the code. For these reasons the prototype must not be used for safety-critical battery decisions.

7. CONCLUSION

This paper described NEOVOLT, a college-level prototype that measures battery voltage with an ESP32 and prepares the ground for current and capacity measurement. We set out the architecture, the measurement relationships, and a capacity-based SOH equation, and we kept these separate from the experimental evidence. The three preliminary voltage comparisons show a small, consistent offset between the ESP32 and a multimeter, which calibration may remove. The demonstration uses a 9 V battery and shows the working concept only; it does not establish the health or remaining life of an EV battery.

7.1 Future Work

Future work should include calibration against reference instruments, safe and repeatable current measurement, and a documented capacity test on a suitable rechargeable battery with controlled equipment, compared against a known reference capacity. Later versions could add battery-specific models, temperature monitoring, and data logging, followed by validation on an EV battery pack under qualified supervision.

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9. REFERENCES

1. Espressif Systems, ESP32 Technical Reference Manual, Shanghai, China. Available: https://www.espressif.com
2. G. L. Plett, Battery Management Systems, Volume I: Battery Modeling, Artech House, Norwood, MA, USA, 2015.
3. K. S. Ng, C.-S. Moo, Y.-P. Chen and Y.-C. Hsieh, Enhanced coulomb counting method for estimating state-of-charge and state-of-health of lithium-ion batteries, Applied Energy, vol. 86, no. 9, pp. 1506–1511, 2009.
4. R. Xiong, L. Li and J. Tian, Towards a smarter battery management system: A critical review on battery state of health monitoring methods, Journal of Power Sources, vol. 405, pp. 18–29, 2018.
5. M. Berecibar et al., Critical review of state of health estimation methods of Li-ion batteries for real applications, Renewable and Sustainable Energy Reviews, vol. 56, pp. 572–587, 2016.