INTERNSHIP REPORT

Joint State-of-Charge and State-of-Health Estimation for Battery Management Systems Using MATLAB/Simulink

Submitted by

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Abstract

This report describes the development of a combined State-of-Charge and State-of-Health estimation system using MATLAB and Simulink. An Extended Kalman Filter is applied on a 12V, 7Ah lead-acid battery model to improve tracking accuracy and compensate for modelling uncertainties.

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1 Internship Overview

Table 1: Internship Summary

Parameter	Details
Project Title	Joint SoC and SoH Estimation for BMS
Student Name	Hari Sankar Saravanan
Duration	15 Working Days (Jan 05 – Jan 19, 2026)
Domain	Battery Management System
Tools Utilized	MATLAB R2025b, Simulink, Simscape Electrical
Key Objectives	Battery Modeling, EKF Implementation, Parameter Estimation

2 System Architecture

The system brings together the battery model, the monitoring logic, and the estimation algorithms.

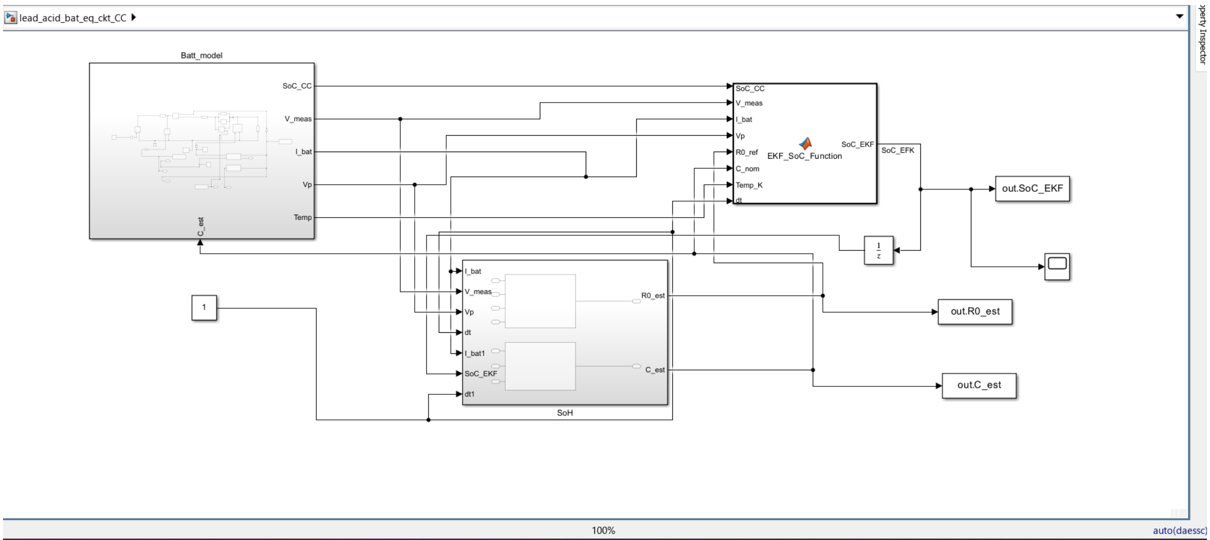


Figure 1: Top-level system architecture

3 Battery Pack Modeling

3.1 Pack Configuration

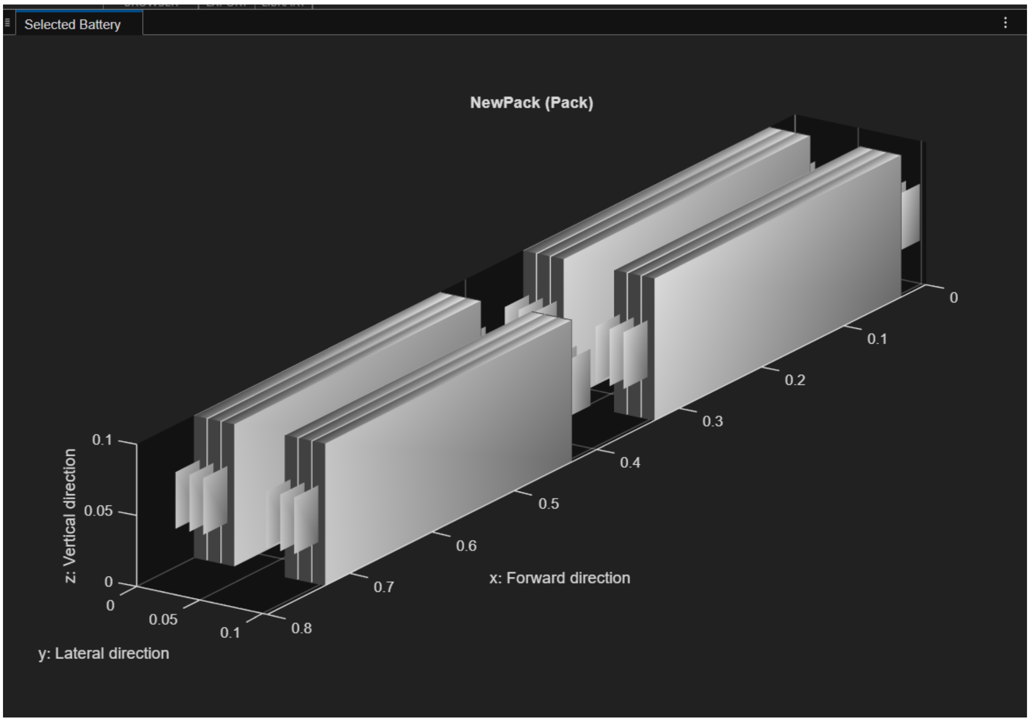


Figure 2: Battery pack used for simulation

3.2 Circuit Design

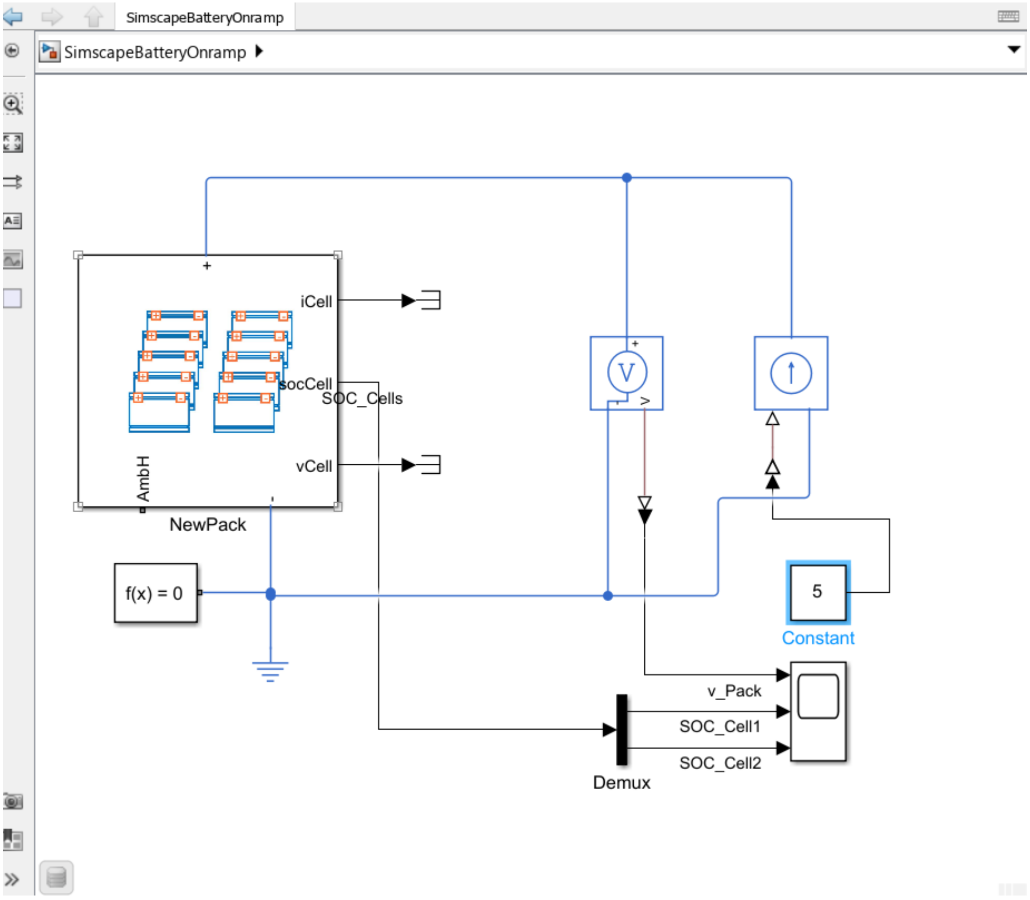
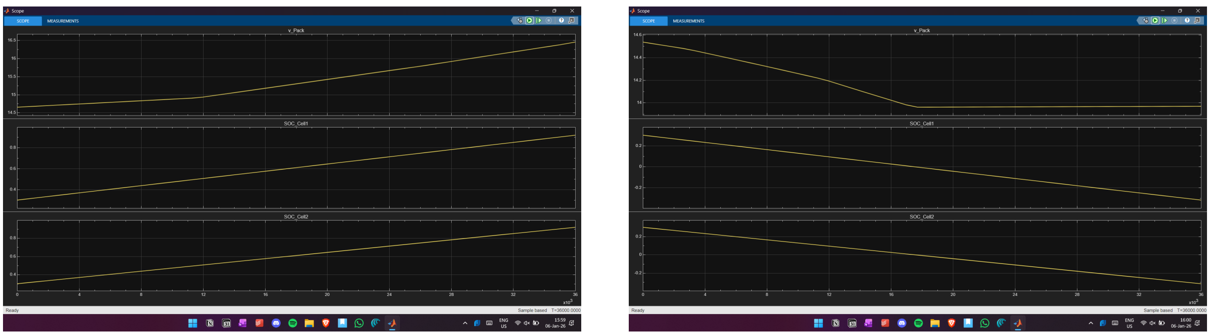


Figure 3: Charging and discharging circuit

3.3 Operational Modes



(a) Charging

(b) Discharging

Figure 4: Current flow during operation

3.4 Charging Algorithm

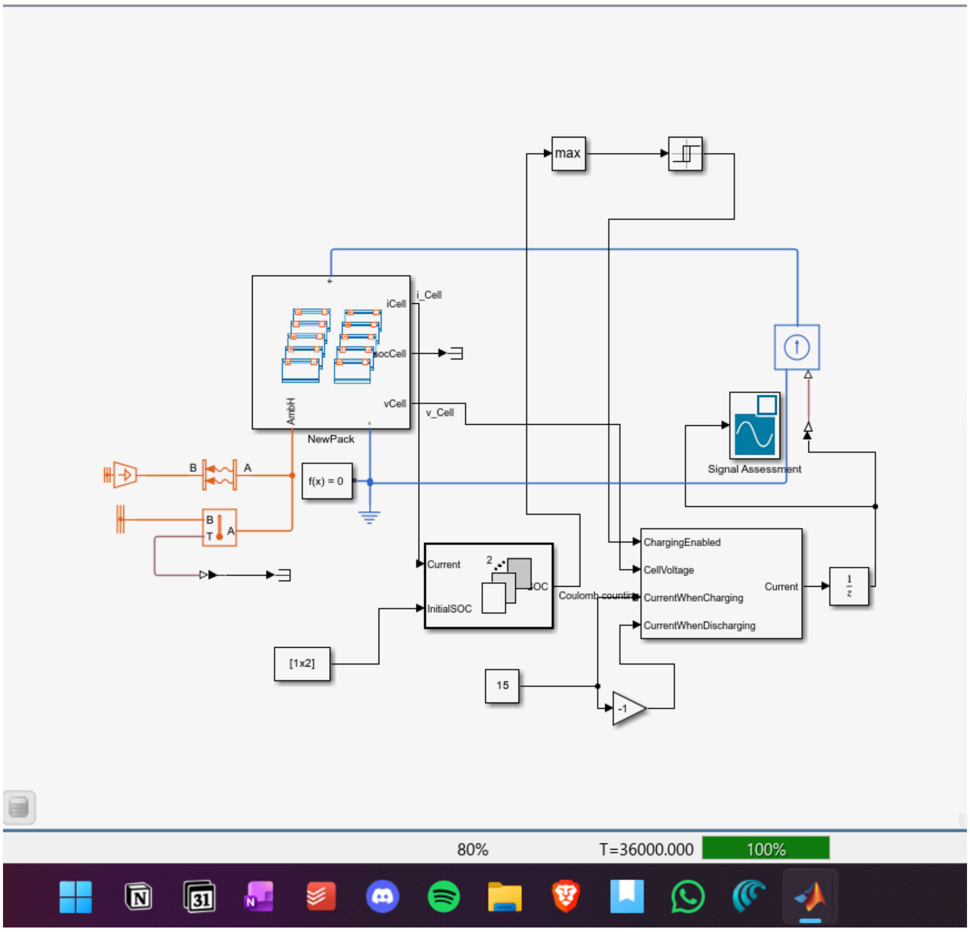


Figure 5: CC–CV charging method

4 Battery Equivalent Circuit Model

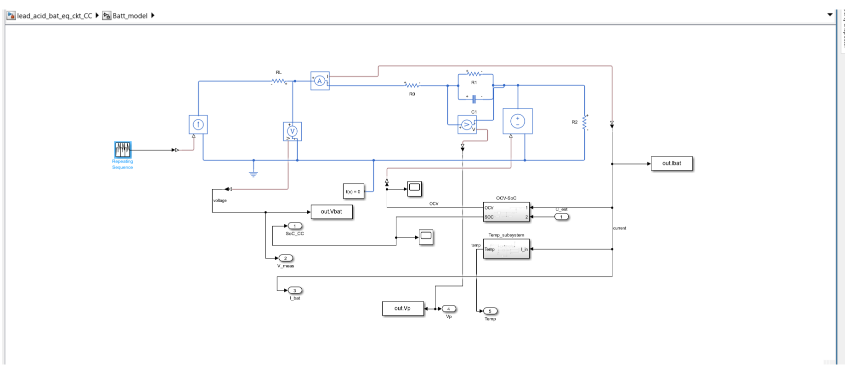


Figure 6: First-order RC battery model

$$V_t = V_{ocv}(\mathrm{SoC}) - IR_0 - V_{rc} \tag{1}$$

5 Simulation Parameters

Table 2: Battery and Circuit Parameters

Parameter	Symbol	Value
Nominal Voltage	V_{nom}	12 V
Rated Capacity	C_{rated}	7 Ah
Nominal Capacity	C_{nom}	25200 C
Internal Resistance	R_0	0.05 Ω
Polarization Capacitance	C_1	1000 F
Load Resistance	R_L	2 Ω
Bleeder Resistance	R_2	10 kΩ
Temperature	T	285.15 K

Table 3: SoC Estimation and EKF Parameters

Parameter	Symbol	Value
Sampling Time	Δt	Variable Step
Initial Covariance	P_0	1×10^{-3}
Process Noise	Q	1×10^{-6}
Measurement Noise	R	1×10^{-2}
Jacobian Perturbation	Δ	1×10^{-3}
Reference Temperature	T_{ref}	298.15 K
Temperature Coefficient	α_T	-0.003
Minimum R_0	–	$0.2R_{0,ref}$

Table 4: OCV–SoC Lookup Table

SoC	OCV (V)
0.0	11.0
0.1	11.5
0.2	11.8
0.3	12.0
0.4	12.2
0.5	12.4
0.6	12.6
0.7	12.8
0.8	13.0
0.9	13.5
1.0	13.8

6 OCV–SoC Characterization

6.1 Equivalent Circuit Model

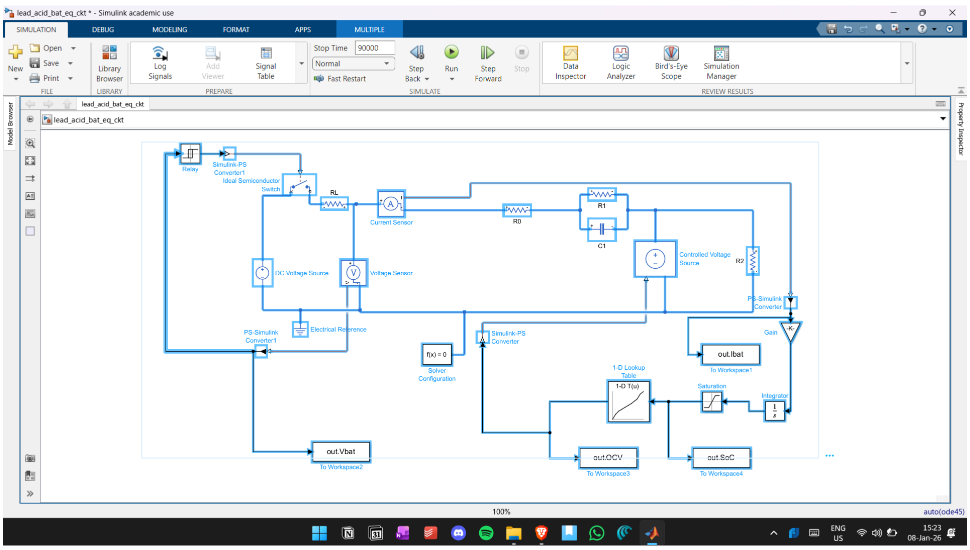


Figure 7: Digital OCV–SoC model

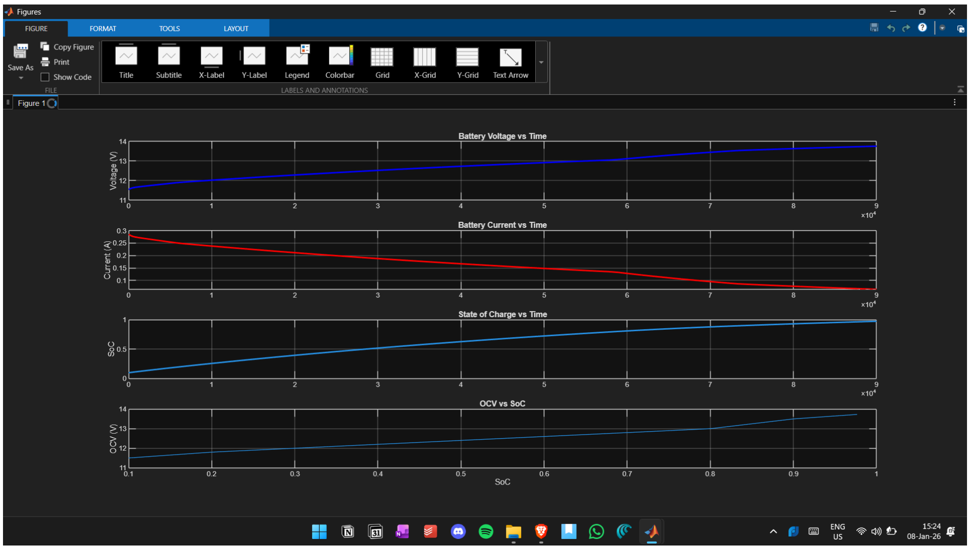


Figure 8: OCV–SoC output characteristics

6.2 Pre-built Model

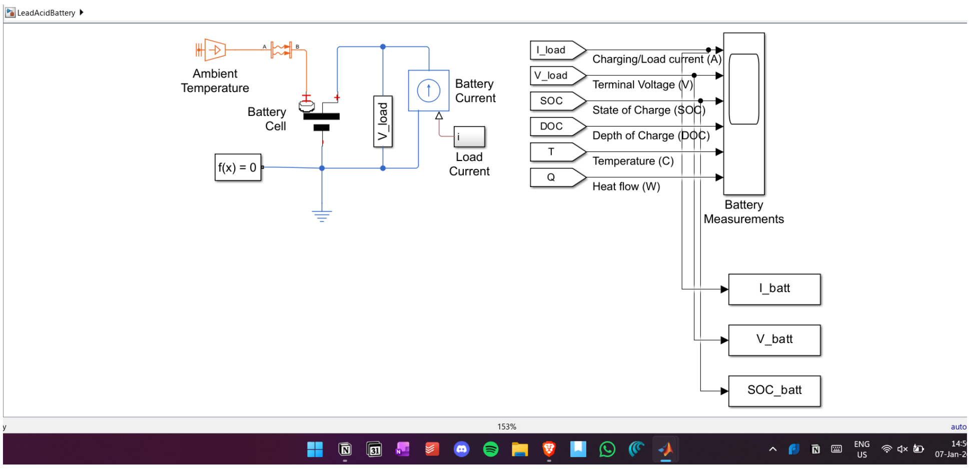


Figure 9: Pre-built OCV model

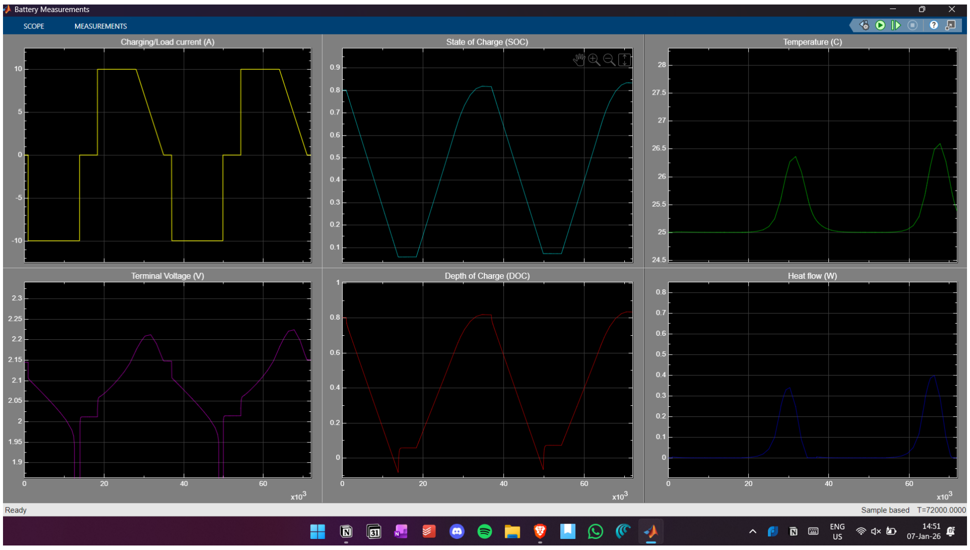


Figure 10: Measured OCV data

7 Discharge Characteristics

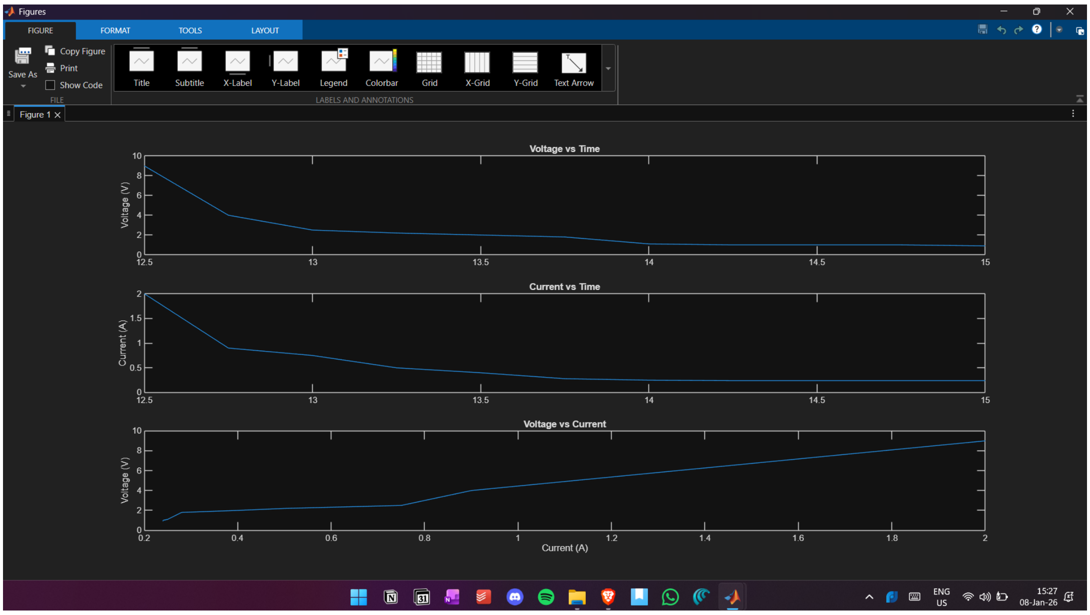


Figure 11: Discharge I–V curve

8 Estimation Algorithm Blocks

8.1 SoC Estimation

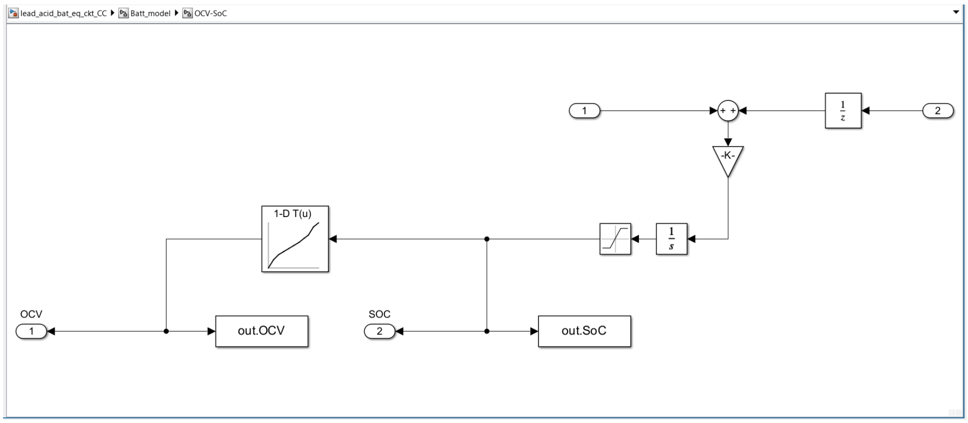


Figure 12: Coulomb counting method

8.2 Temperature Compensation

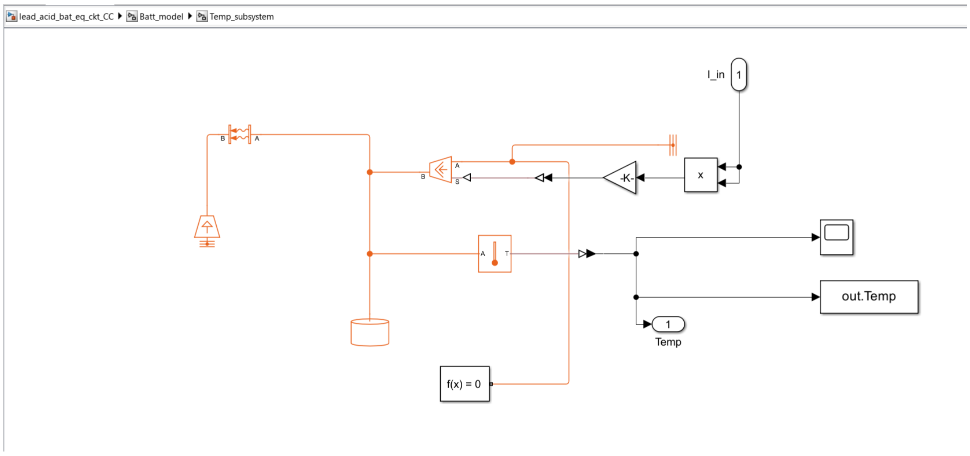


Figure 13: Temperature validation

8.3 State of Health

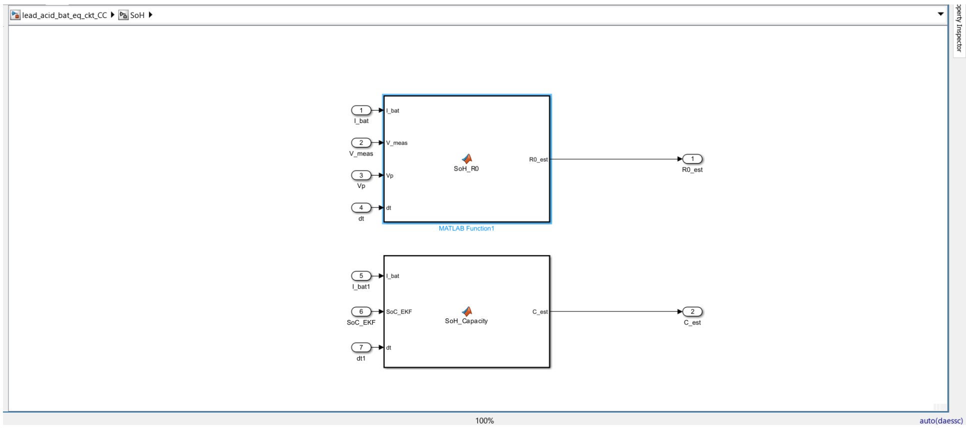


Figure 14: SoH estimation block

9 Simulation Results

9.1 Dashboard Overview

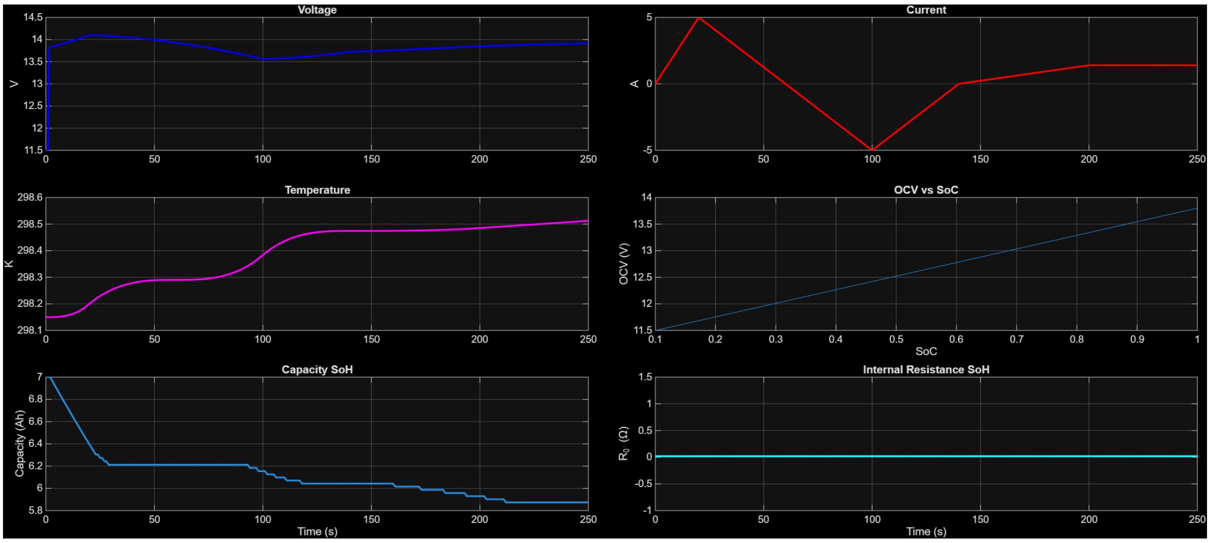


Figure 15: Dashboard for real-time estimation

9.2 SoC Estimation Accuracy

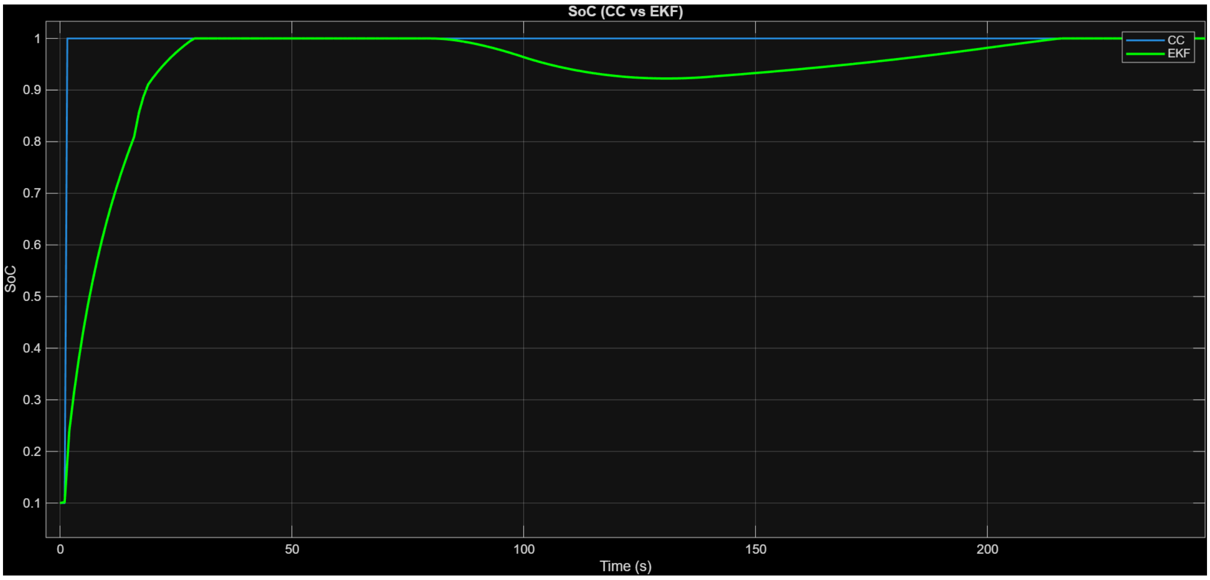


Figure 16: True SoC compared with EKF estimate

9.3 SoH Tracking

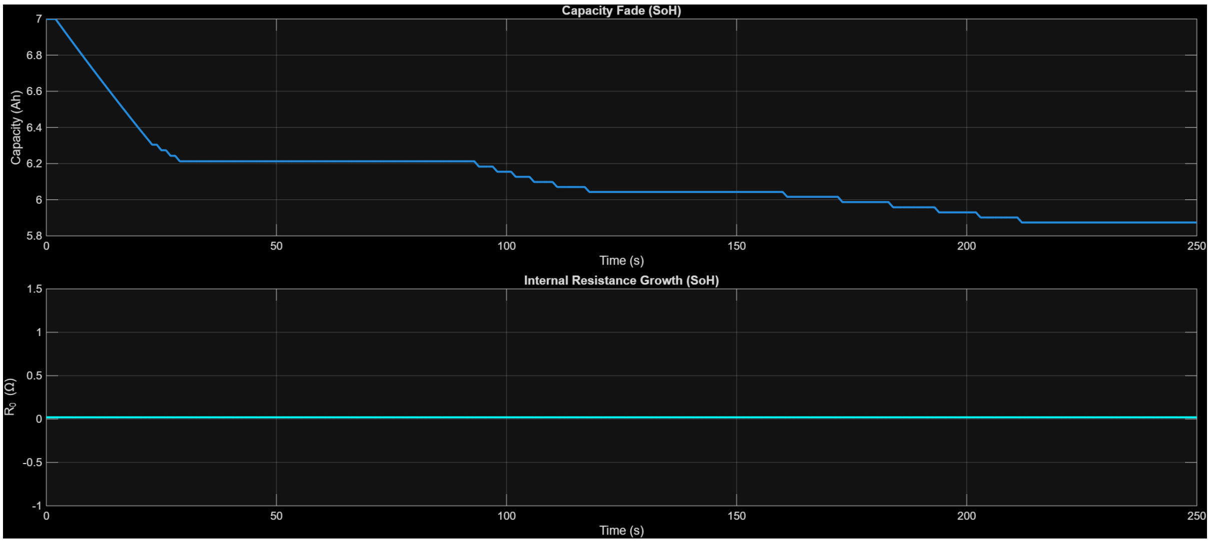


Figure 17: Resistance and capacity evolution

10 Work Log

Table 5: Daily Activity Log

Day	Task
1–3	Battery plant model development
4–6	OCV characterization and Coulomb counting
7–9	EKF formulation and tuning
10–12	SoH logic development
13–15	Final integration and testing

11 Conclusion

The developed joint estimator provided accurate State-of-Charge prediction and consistent State-of-Health tracking. The Extended Kalman Filter improved stability and reduced drift, while the SoH logic captured both resistance change and capacity fade effectively.