Design of Battery Charger with IoT Capabilities for Electric Bikes

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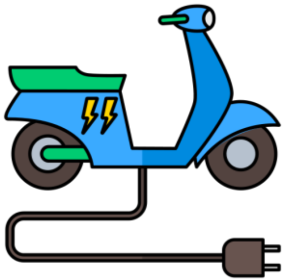
Introduction

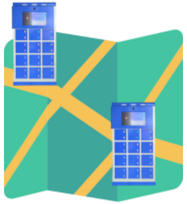
New policies pushed major development in E-bike industry



Conventional E-bike charging takes a long time

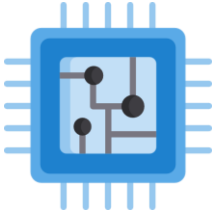
E-bike rental services with swappable batteries → reduce charging time

Problem

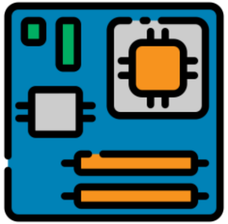


Some users have difficulties in accessing a BSS

Companies need a way to monitor chargers

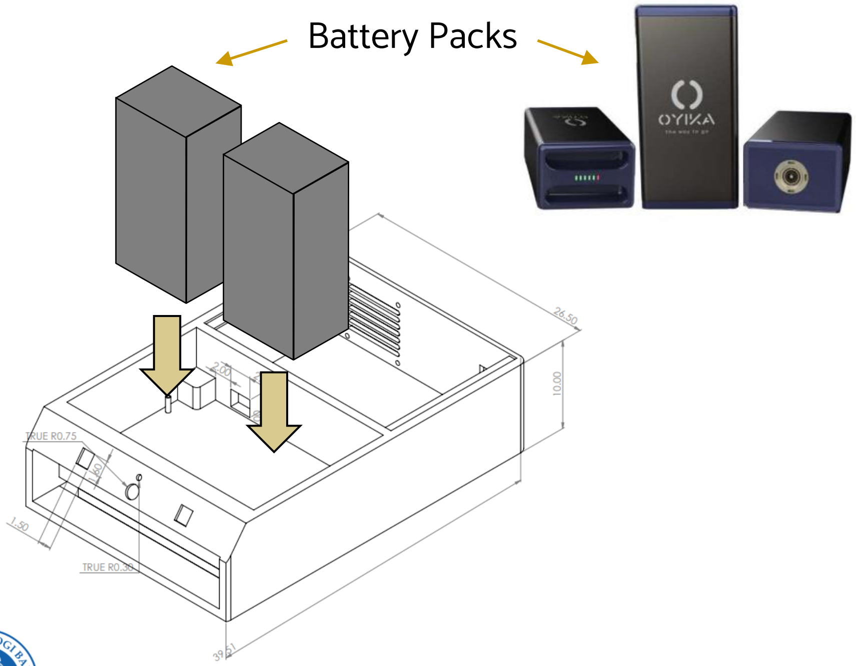


Proprietary battery packs have a safety system that needs to be disabled



MCU-controlled charger is proposed

Proposed Solution

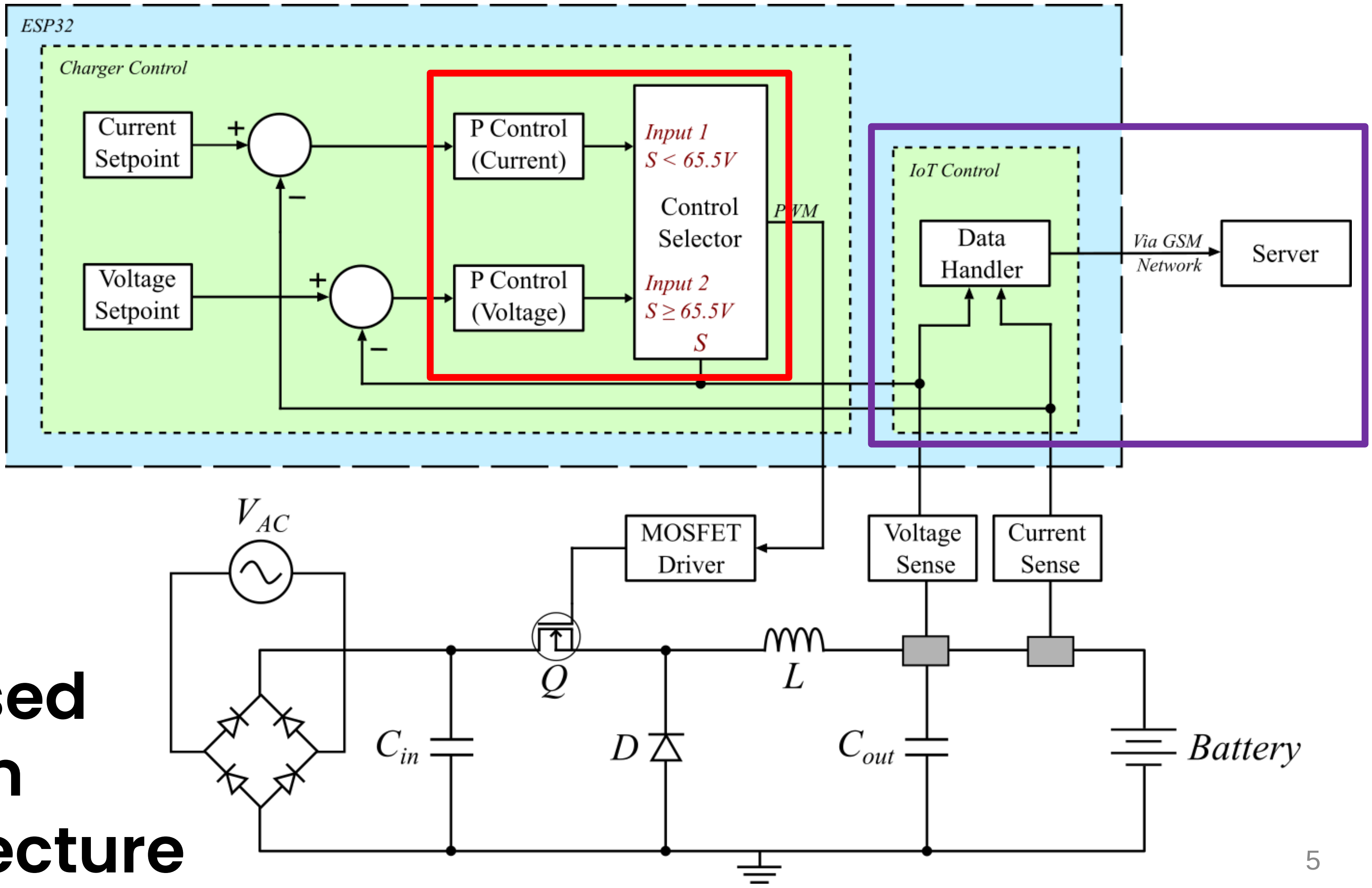


Smart **Charger**

- Capable of charging a 60.8V and 11.2Ah battery pack
- Capable of being monitored and controlled

Maximum charging current 10A, power output around 600W

Low enough to be used in most of Indonesia’s house



Proposed System Architecture

Charger Subsystem

Proposed Concept

- Non-isolated SMPS buck converter topology
- Two charging modes
  - *Fast Charging* at around 10A
  - *Slow Charging* at 5A
- CCCV charging method, transition at 65.5V nominal voltage (est. 85% SoC)
- Passive RC snubber for the switching device

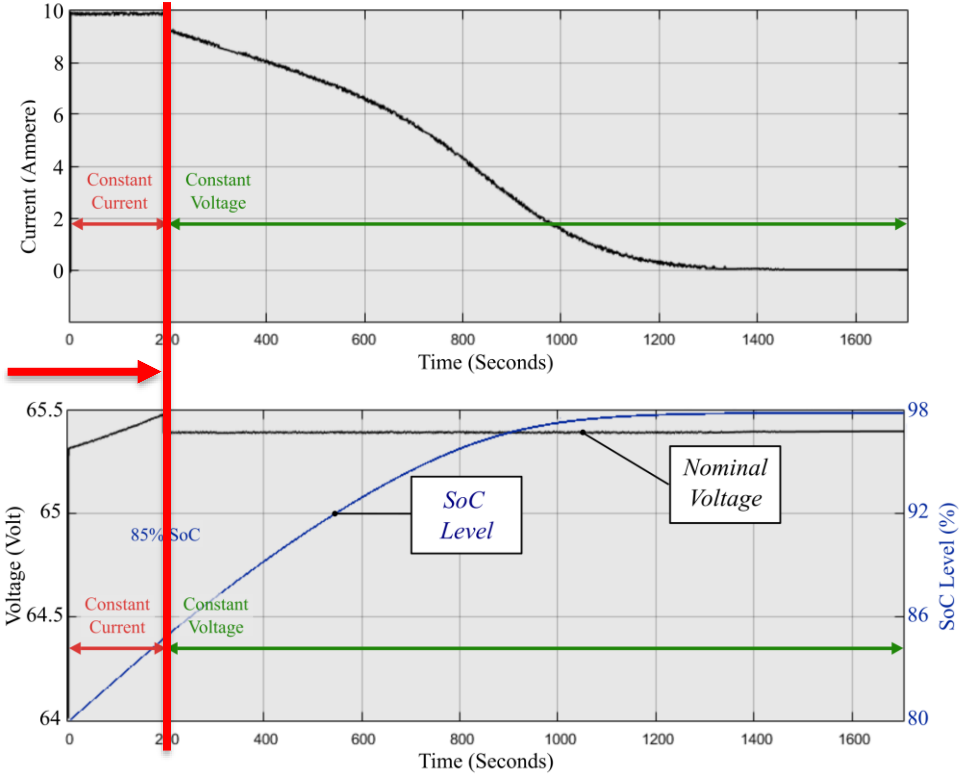
Buck Converter Specifications

Parameter	Value
Vin	220V AC
Vout (nominal)	60.8V DC
f_s	23kHz (TLP250)
ΔI_o	0.35

Charger Subsystem

Simulation Results – CC/CV transition

CC-CV Transition Mark



Current output

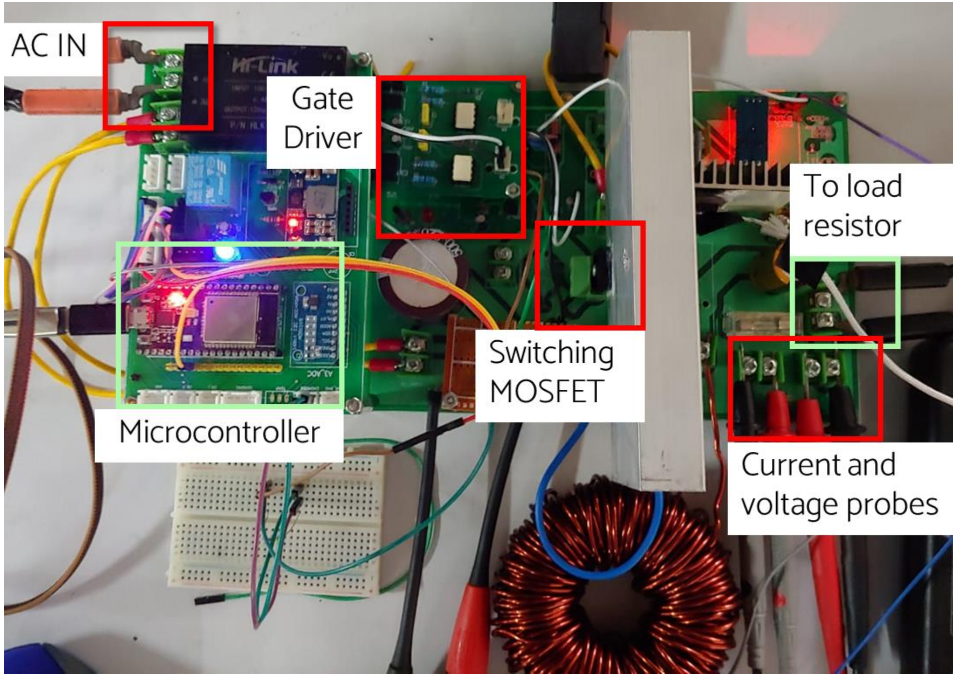
Constant in CC phase
Decreases in CV phase

Voltage and SoC Level

Increases in CC phase
Constant in CV phase

Charger Subsystem

Experiment Setup

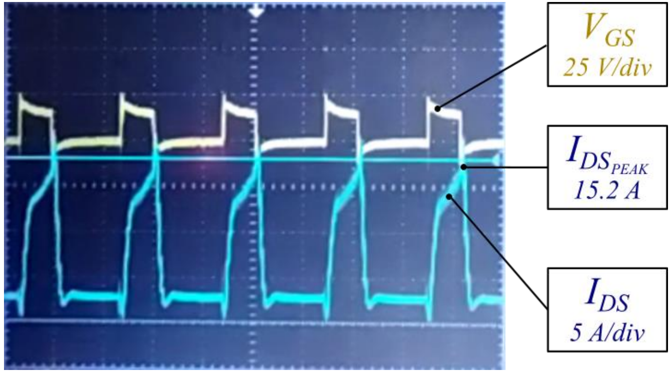


Initial tests done with a load resistor

Due to the unavailability of cores with accurate datasheet in the domestic market, a core with a very low μ_R is selected

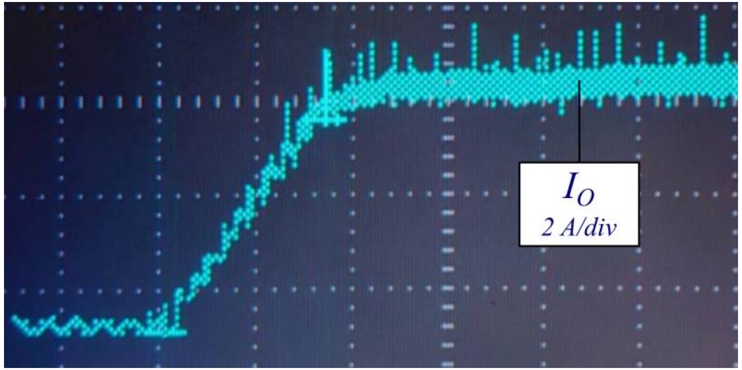
Charger Subsystem

Experiment Results



Switching current

Peak current below switch’s operating range



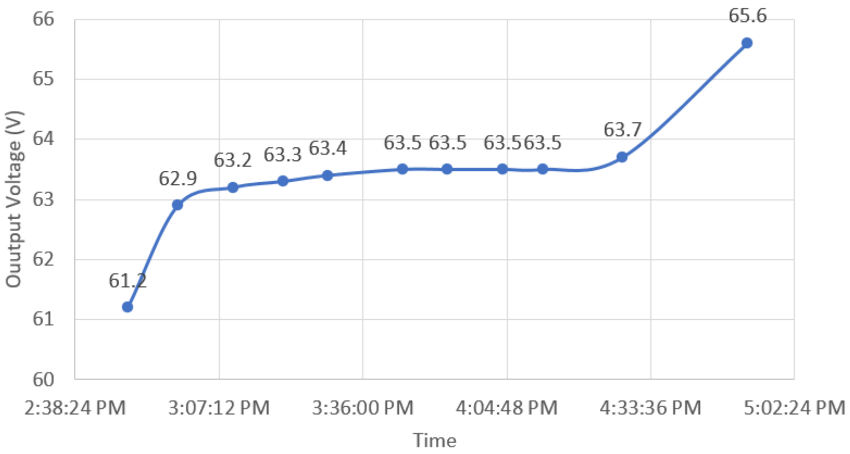
Output current connected to a battery

Response time 800ms
Ripple ~ 25% at 5A output

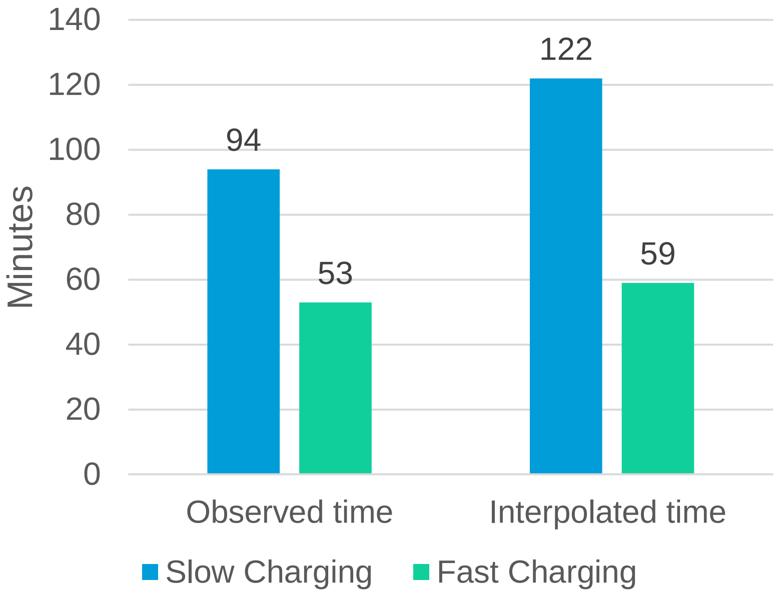
Charger Subsystem

Experiment Results

Voltage output increases with SoC



Charging time for the two charging modes



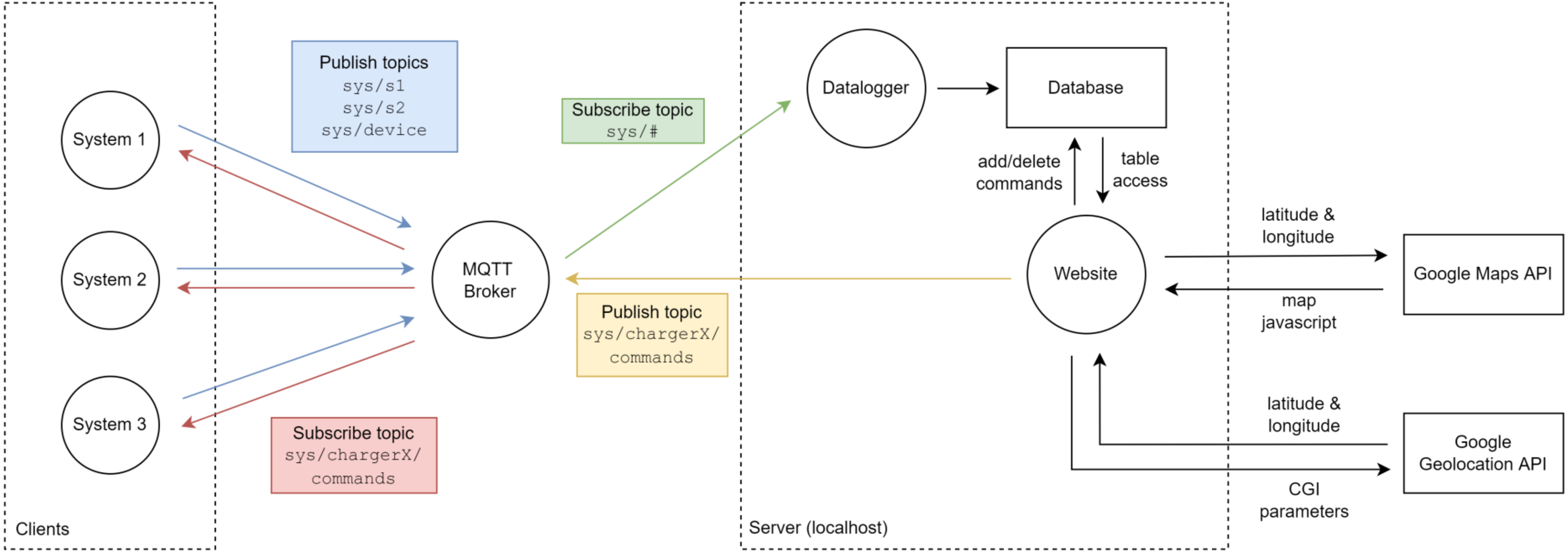
IoT Subsystem

Proposed Concept

- Sends data to a database when an event is triggered (insersion, removal, finished charging)
  - Battery info (voltage, serial number, SoC, SoH)
  - Timestamp
  - Location
- Uses 2G network – MQTT protocol
- Server uses Python Flask as a framework, SQLite as database
- Rudimentary web dashboard to view data logging and location

IoT Subsystem

Proposed Infrastructure



IoT Subsystem

Implementation Results – Web Dashboard

Shows current slot condition

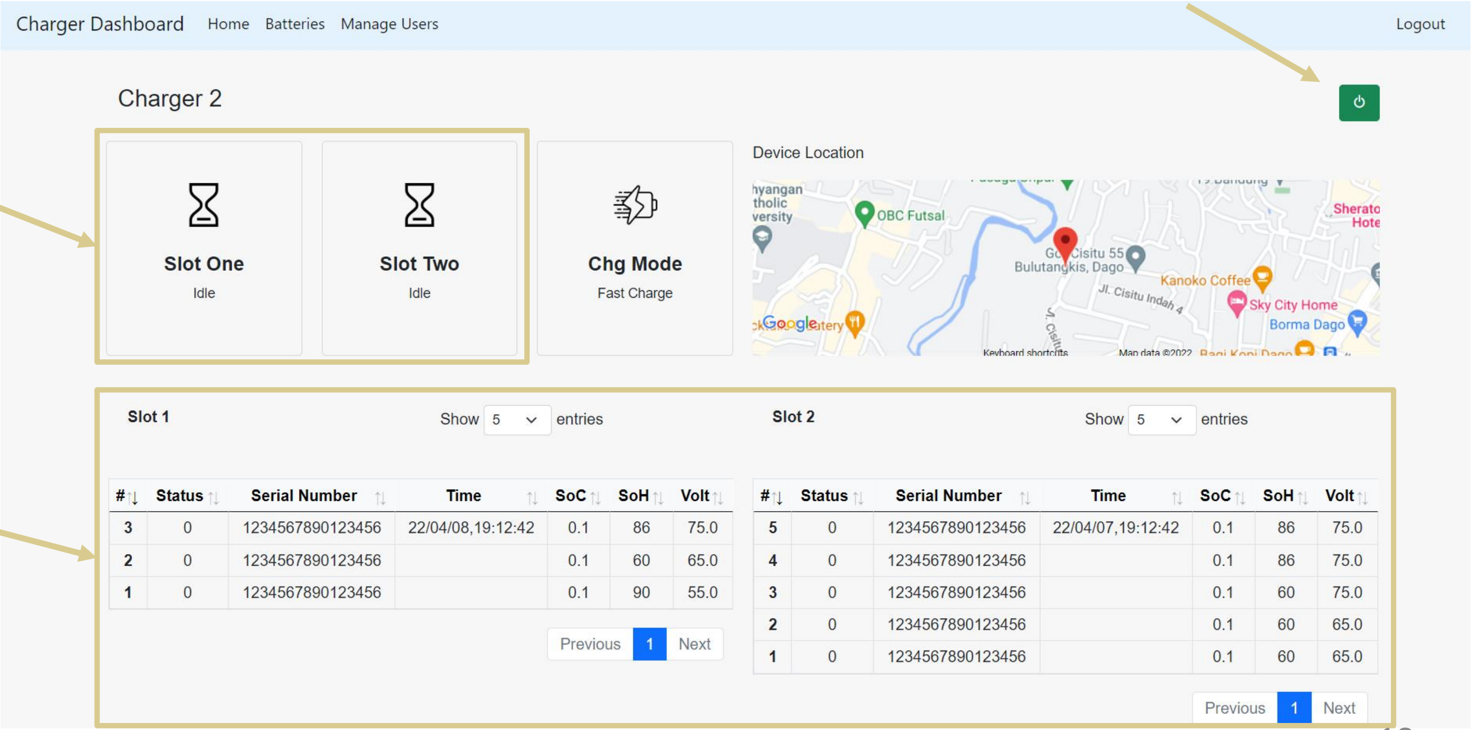
Idle

Charging

Charged

Datalogging history Slot 1 (left) 2 (right)

Remote ON/OFF



Slot 1

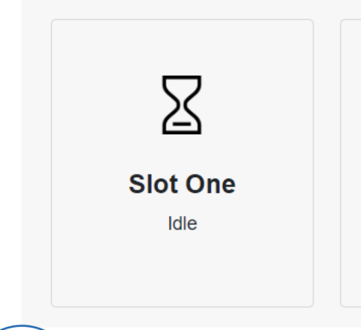
#	Status	Serial Number	Time	SoC	SoH	Volt
3	0	1234567890123456	22/04/08,19:12:42	0.1	86	75.0
2	0	1234567890123456		0.1	60	65.0
1	0	1234567890123456		0.1	90	55.0

Slot 2

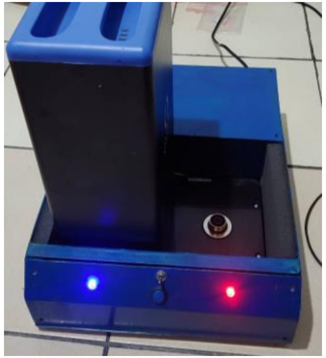
#	Status	Serial Number	Time	SoC	SoH	Volt
5	0	1234567890123456	22/04/07,19:12:42	0.1	86	75.0
4	0	1234567890123456		0.1	86	75.0
3	0	1234567890123456		0.1	60	75.0
2	0	1234567890123456		0.1	60	65.0
1	0	1234567890123456		0.1	60	65.0

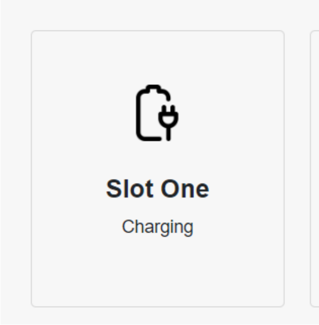
IoT Subsystem

Implementation Results – Charger System

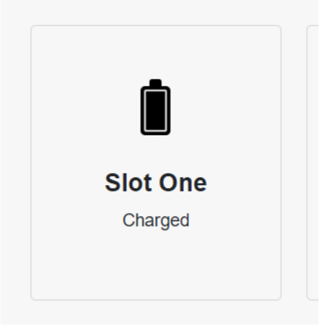


Idle





Charging



Finished Charging

Top – obtained location
Bottom – actual testing location
Accuracy ~100m

Conclusion

Battery charging system

Charger output : 60.8V, 10A

Maximum power of 650W (65V, 10A right before transitioning to CV phase)

Remote monitoring and control

Important parameters that can be observed:

Location
Charging Status
Charging History

Suggestion

1. Inductor selection can be improved to increase portability and to minimize core losses
2. Upgrade database to mySQL for a more robust system

Thank You

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Appendix 1. Buck Converter Calculation

Determining inductor peak current, assuming 35% ripple output

$$i_{L,peak} = i_{out} + \frac{\Delta i_L}{2}$$

$$i_{L,peak} = 10 + \frac{10 \cdot 0.35}{2}$$

$$i_{L,peak} = 11.75\ A$$ → 2mm winding conductor

With a 661 μH inductor, the optimum switching frequency can be calculated

$$f_{sw} = \frac{V_o(1-D)}{L \cdot \Delta i_L}$$

$$f_{sw} = \frac{68 \cdot (1 - \frac{68}{311})}{661 \times 10^{-6} \cdot 0.35 \cdot 10} \approx 22.97\ kHz$$