



**ĐẠI HỌC
BÁCH KHOA HÀ NỘI**
HANOI UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Electric mobility in Vietnam and a home-made simulation tool for urban railway

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Content

- 1. e-Mobility in Vietnam**
- 2. EMR-based simulation tools for train**
- 3. Matlab/Simulink vs Home-made tool**
- 4. What's next?**



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Electric mobility in Vietnam: some snapshots

≈735,000

electric two-wheelers sold in 2025
Over 20% of new two-wheeler sales

Nearly 40%

of new car sales were electric in 2025

**Vietnam leads Southeast Asia in
electric car and two-wheeler sales.**

Sources: IEA (2025 sales), Dat Bike. Range figures are manufacturer claims.



Dat Bike

Made in Ho Chi Minh City
Quantum S: plug-in charging
200–285 km claimed range

Battery-swapping model

Selex Motors: Vietnamese maker of Camel motorbikes, battery packs and swap stations.

≈2 minutes

for a battery swap
118 stations, December 2025

Designed for delivery

Battery rental lowers upfront cost.
Swap cabinets and an app keep
working riders on the road.

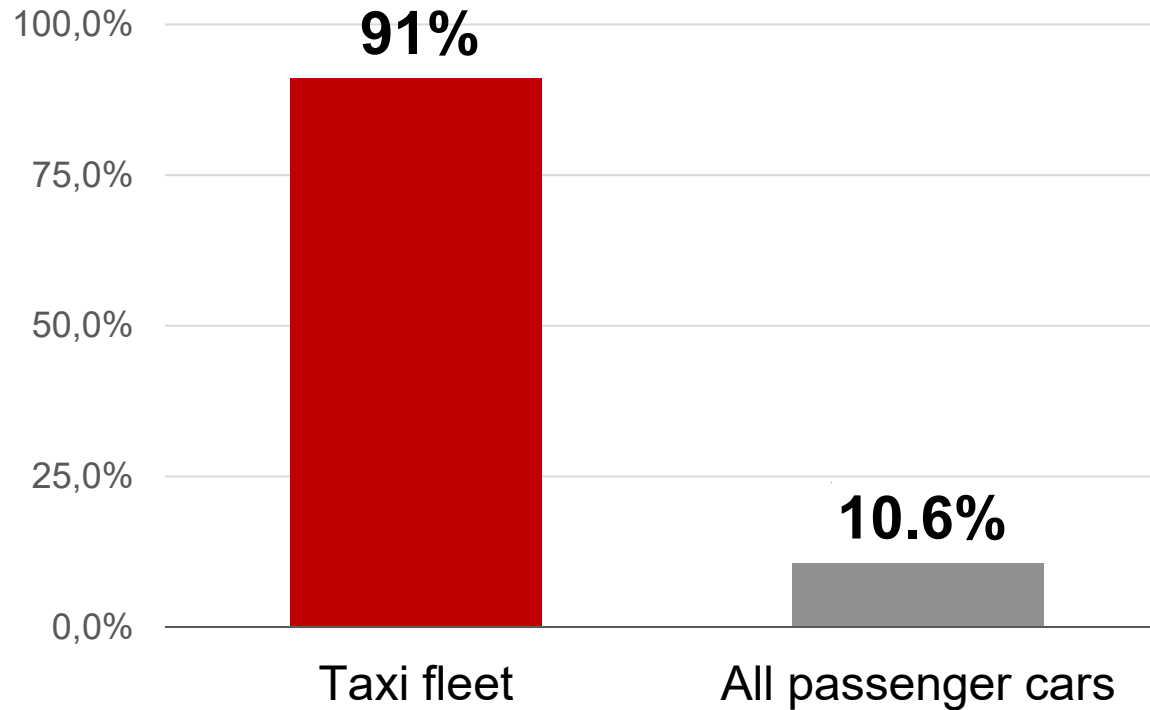


Fast battery swaps protect delivery riders' earning time.

Later, but beyond Selex: V-Green installed 4,500 stations (January 2026)

Electric taxis are far ahead of the car fleet

Electric share of the registered fleet in HCMC, June 2026



Xanh SM / Green SM electric taxis

Passenger services can electrify rapidly when vehicles run all day.

Source: Ministry of Construction, June 2026. Taxi category excludes some ride-hailing cars.

Charging network supports adoption



Public charging for VinFast cars. Photo: VinFast, 2022.

150,000+

reported charging ports
for cars + electric motorbikes

34 provinces and cities

Vietnam-wide coverage
reported January 2026

V-Green operates the network
Direct and franchised sites

Fleet insight: reliable charging access helps taxis maintain daily mileage.

Public transport and other electric modes



HCMC Metro Line 1

≈41.3 million

metro passenger trips in 2025
Hanoi + Ho Chi Minh City

627 electric buses

on 47 HCMC routes
January 2026

Urban trips

Shared e-bikes and
electric motorbike taxis

Goods

Delivery motorbikes, vans
and electric trucks

Water and rail

Electric tourism boats
Intercity rail still diesel

Sources: Hanoi Metro, VOV, Ministry of Construction. Other modes operate at varying scales.

Bus and metro development plans

2030

100%

electric / green-energy
buses in Hanoi + HCMC

2035

≈500 km

Hanoi urban rail
investment plan

2045

≈979 km

Hanoi urban rail
master plan

255 km

HCMC urban rail target
8 priority projects

532 km

HCMC urban rail target

Across all stages

Bus feeders, metro
and satellite towns

Bus connections turn metro lines into a usable citywide network.

Plans, not guaranteed openings. Electric / green-energy targets can include gas buses.

Sources: Hanoi / Vietnam Government Portal (2025–26), HCMC People's Council (Jul–Aug 2026).



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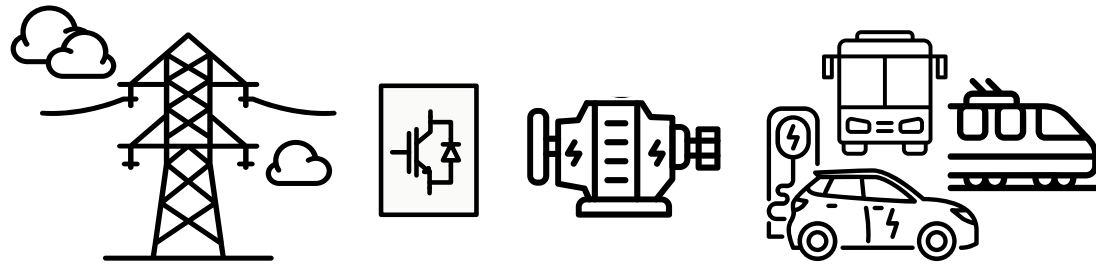
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Title of your slide



- Proprietary & Costly licenses
- Black-box numerical solvers



- Open source & Free of charge
- Transparent implementation



➤ **Objective: Develop an open-source tool based on EMR for urban railway powertrain system**

Urban train traction subsystem

A. Modeling using EMR formalism

▪ Electric drive:

$$\begin{cases} u_{dc} i_{drive} = T_m \omega_m \eta_{ed}^k \\ T_m = T_{m,ref} \end{cases} \text{ with } \begin{cases} k = 1, T_m \omega_m < 0 \\ k = -1, T_m \omega_m > 0 \end{cases}$$

▪ Gearbox and bogie:

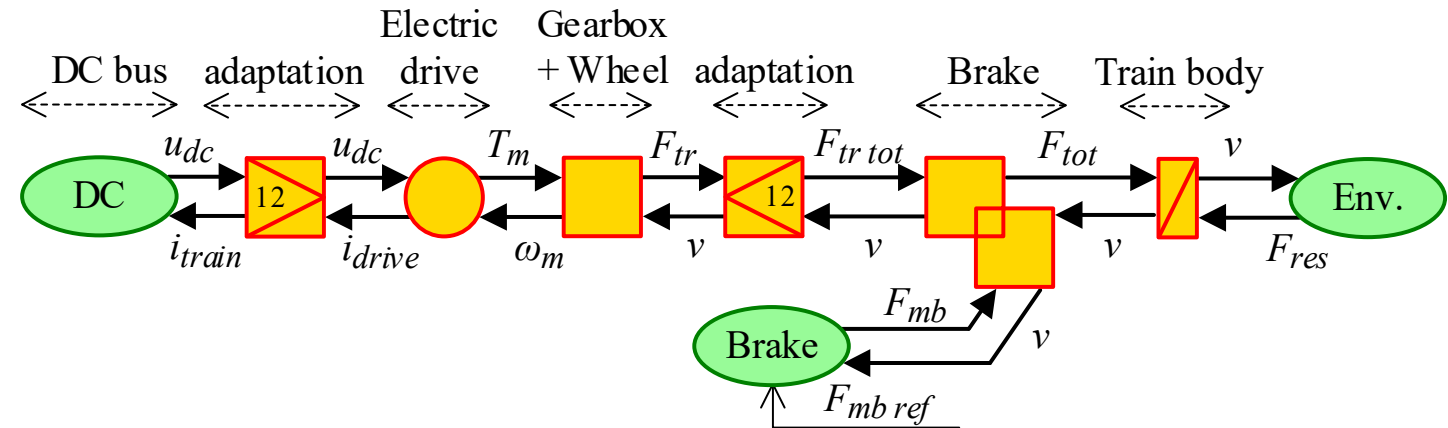
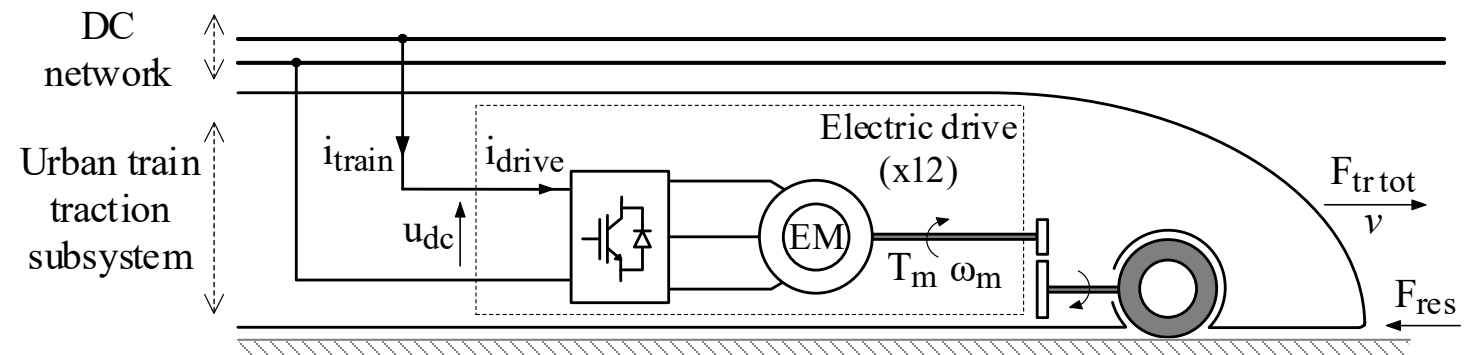
$$\begin{cases} \omega_m = k_{tm} v \\ F_{tr} = n_{gear}^k k_{tm} T_m \\ k_{tm} = \frac{1}{r_{wh}} k_{gear} \end{cases} \text{ with } \begin{cases} k = 1, F_{tr} v > 0 \\ k = -1, F_{tr} v < 0 \end{cases}$$

▪ Brake:

$$\begin{cases} v \text{ common} \\ F_{tot} = F_{tr tot} - F_{mb} \end{cases} \text{ with } F_{mb} = F_{mb ref}$$

▪ Train body:

$$F_{tot} - F_{res} = M_{train} \frac{d}{dt} v$$



Urban train traction subsystem

B. Inversion-based speed control

- Closed-loop speed control (classical IP control):

$$F_{tot\ ref} = K_{iv} \int (v_{ref} - v_{meas}) dt - K_{pv} i_{meas}$$

- Distribution:

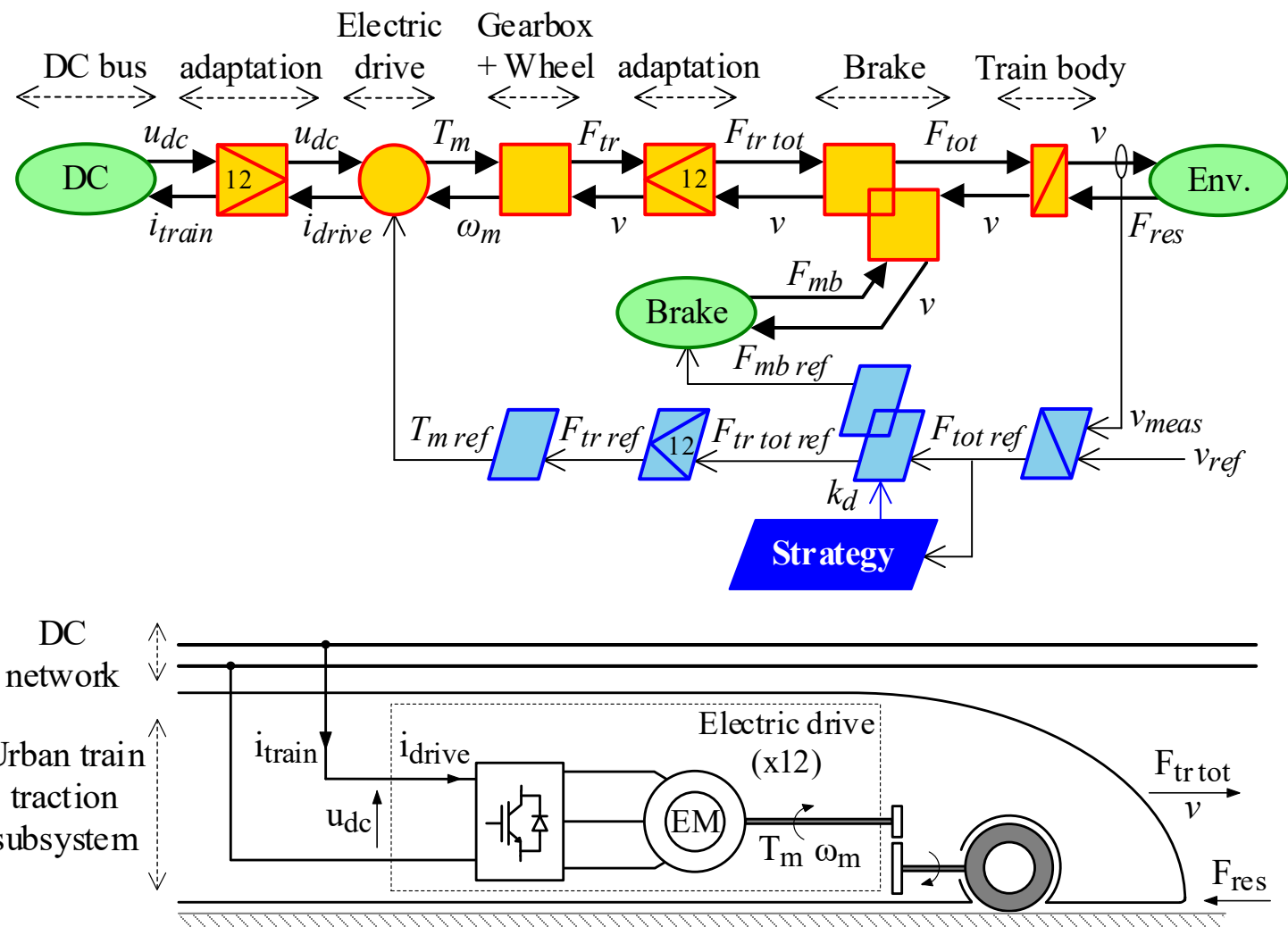
$$\begin{cases} F_{tr\ tot\ ref} = k_d F_{tot\ ref} \\ F_{mb\ ref} = (1 - k_d) F_{tot\ ref} \end{cases}$$

- Strategy:

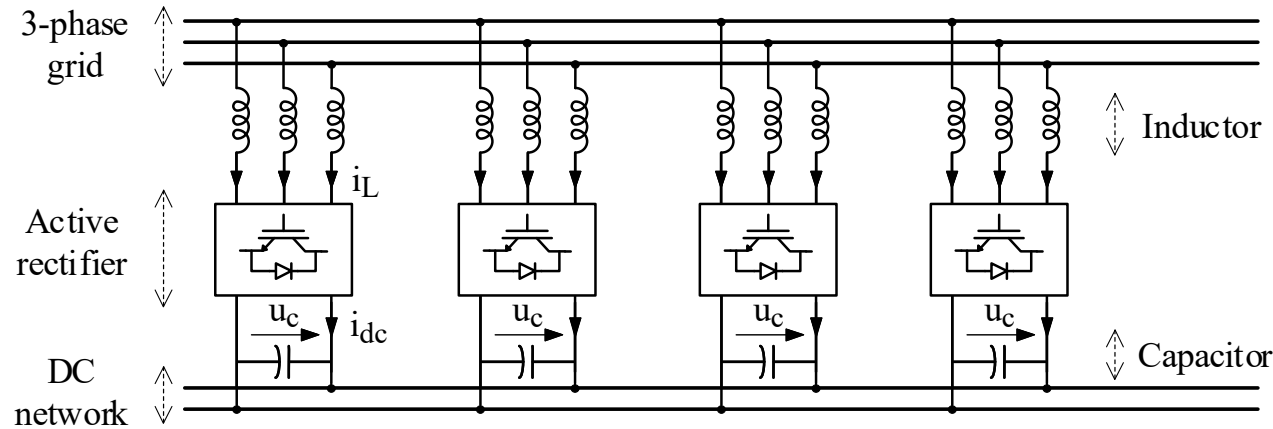
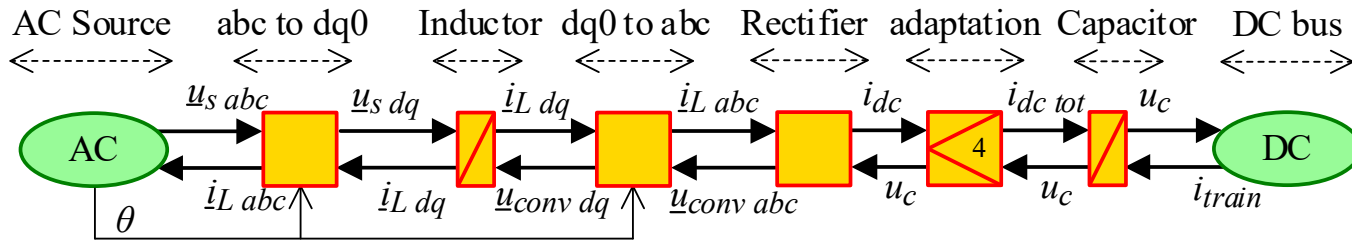
$$\begin{cases} k_d = 1, \text{ for traction mode} \\ k_d \leq 1, \text{ for deceleration mode} \end{cases}$$

- Mechanical transmission inversion:

$$T_{m\ ref} = \frac{1}{k_{tm}} F_{tr\ ref}$$



Active rectifier power supply



A. Modeling using EMR formalism

Inductor:

$$\begin{cases} u_{s,d} - u_{conv,d} = L \frac{di_{L,d}}{dt} + Ri_{L,d} - \omega L i_{L,q} \\ u_{s,q} - u_{conv,q} = L \frac{di_{L,q}}{dt} + Ri_{L,q} + \omega L i_{L,d} \end{cases}$$

Rectifier:

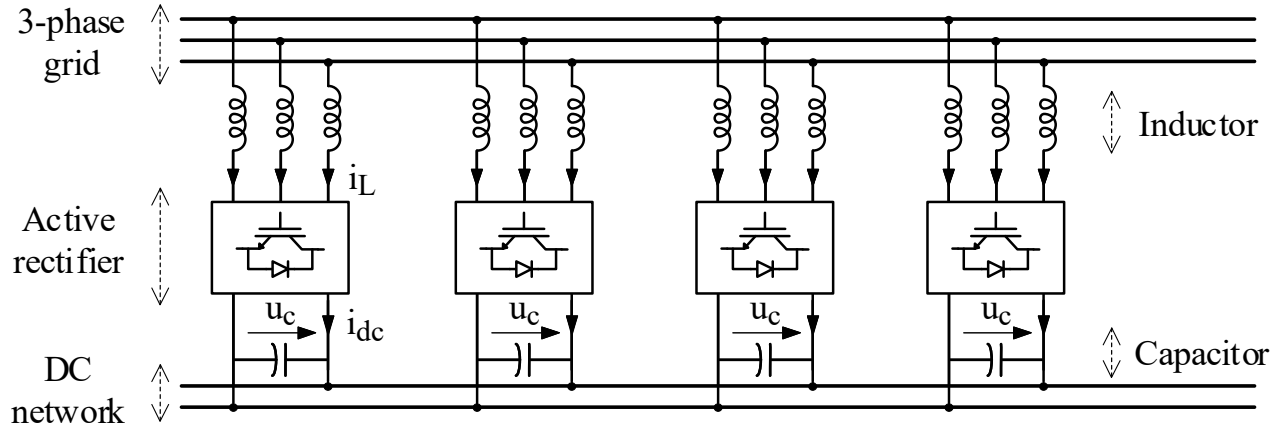
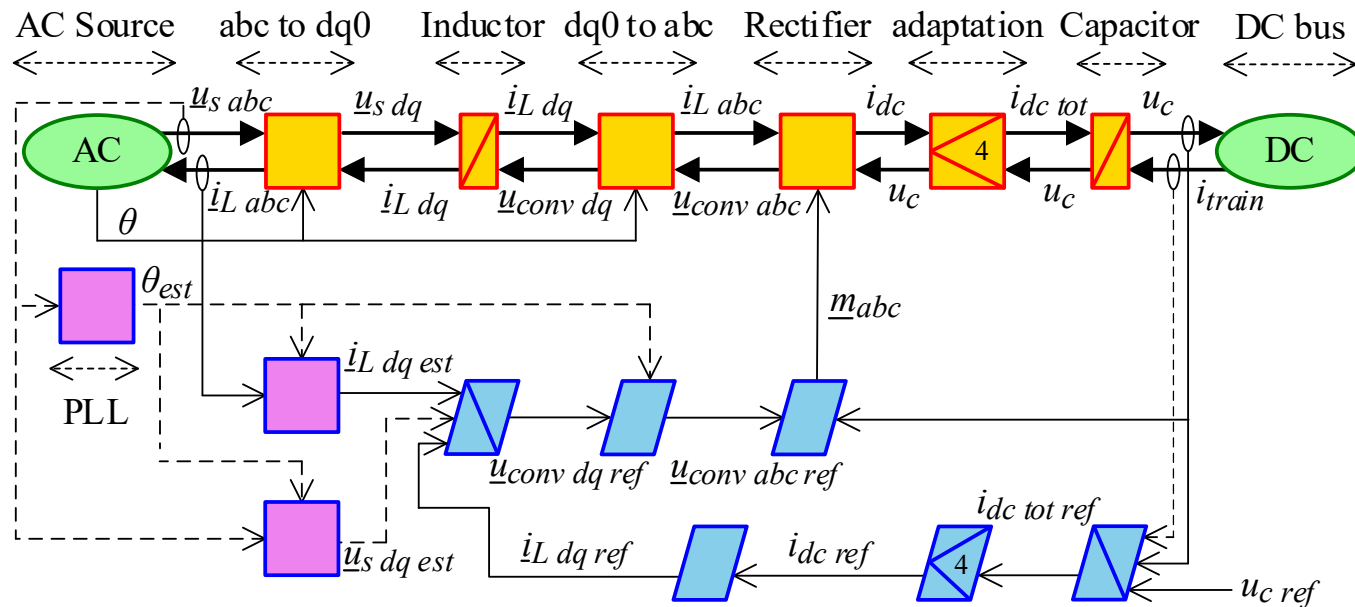
$$\begin{cases} u_{conv,a} = \frac{u_c}{2} m_a \\ u_{conv,b} = \frac{u_c}{2} m_b \\ u_{conv,c} = \frac{u_c}{2} m_c \end{cases}$$

$$i_{dc} = \frac{1}{2} (i_{L,a} m_a + i_{L,b} m_b + i_{L,c} m_c)$$

Capacitor:

$$i_{dc\ tot} - i_{train} = 4C \frac{du_c}{dt}$$

Active rectifier power supply



B. Inversion-based voltage and current control

- Closed-loop voltage control (classical PI control):

$$i_{dc\ tot\ ref} = C_u(u_{c\ ref} - u_{c\ meas}) + i_{train}$$

- Rectifier (current relationship inversion):

$$\begin{cases} i_{L,d\ ref} = i_{dc\ ref} \\ i_{L,q\ ref} = 0 \end{cases} \text{ with } i_{dc\ ref} = \frac{i_{dc\ tot\ ref}}{4}$$

- Closed-loop current control (classical PI control):

$$\underline{u}_{conv\ dq\ ref} = C_i(\underline{i}_{L\ dq\ ref} - \underline{i}_{L\ dq\ est}) + \underline{u}_{s\ dq\ est}$$

- Rectifier modulation:

$$\underline{m}_{abc} = \frac{2\underline{u}_{conv\ abc\ ref}}{u_c}$$



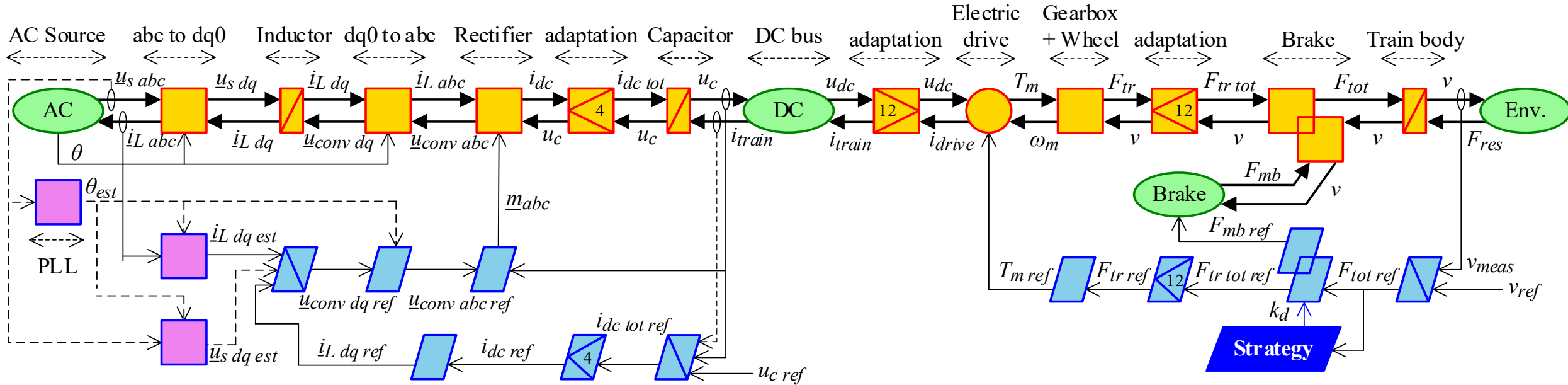
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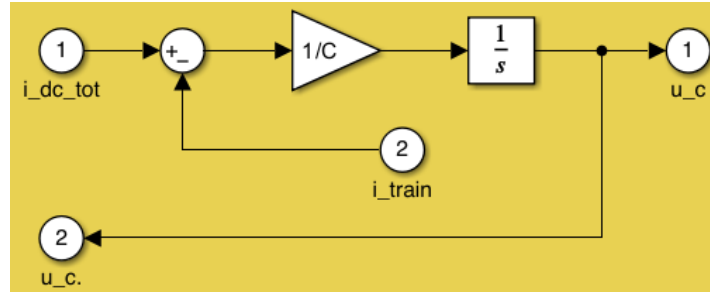
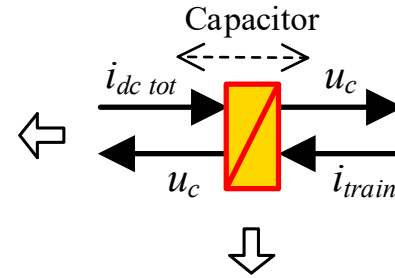
Matlab/Simulink vs Python simulation based on EMR



vs.



EMR defines how we should organize the element model code



```
class Capacitor:
    def __init__(self, C, Ts, u_c_init):
        self.C = C                # Capacitance of the DC-link [F]
        self.Ts = Ts              # Simulation time step [s]
        self.u_c = u_c_init       # Initial DC-link voltage [V]

    def Input(self, i_dc_tot, i_load):
        self.i_dc_tot = i_dc_tot  # Total DC current [A]
        self.i_load = i_load      # Current consumed by load [A]

    def Dynamic(self):
        # Numerical integration using the Forward Euler method
        self.u_c += (self.i_dc_tot - self.i_load) * self.Ts / self.C

    def Output(self):
        return self.u_c           # Updated DC-link voltage [V]
```

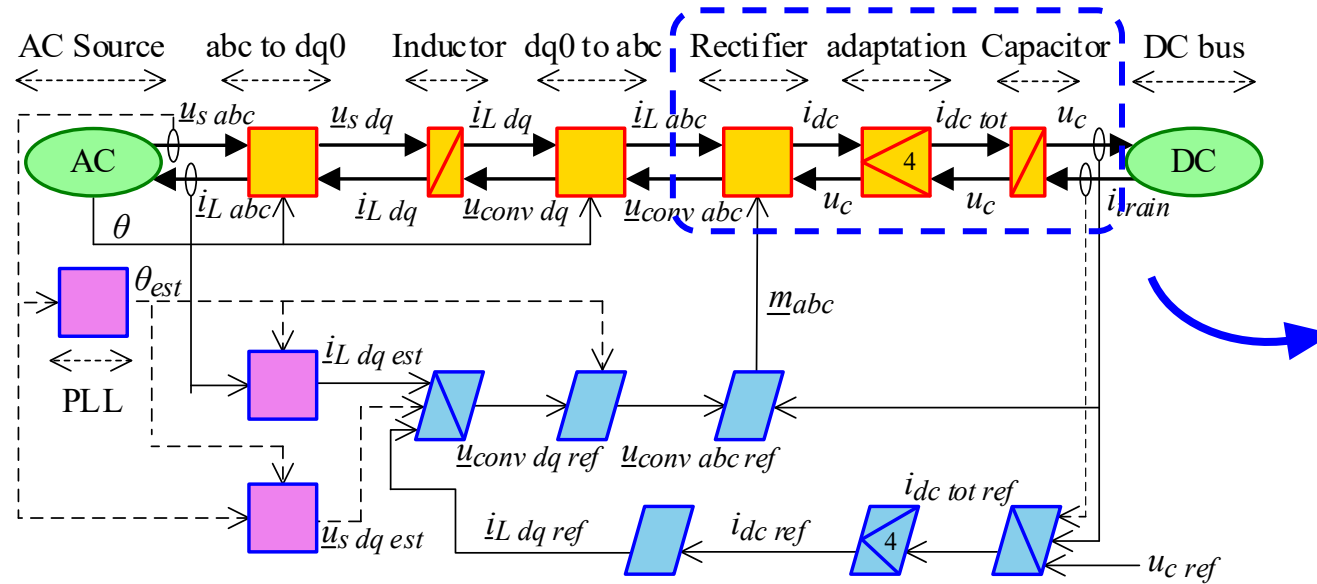
→ Parameter initialization

→ Input acquisition

→ State update

→ Output generation

EMR defines how we should organize the system model code



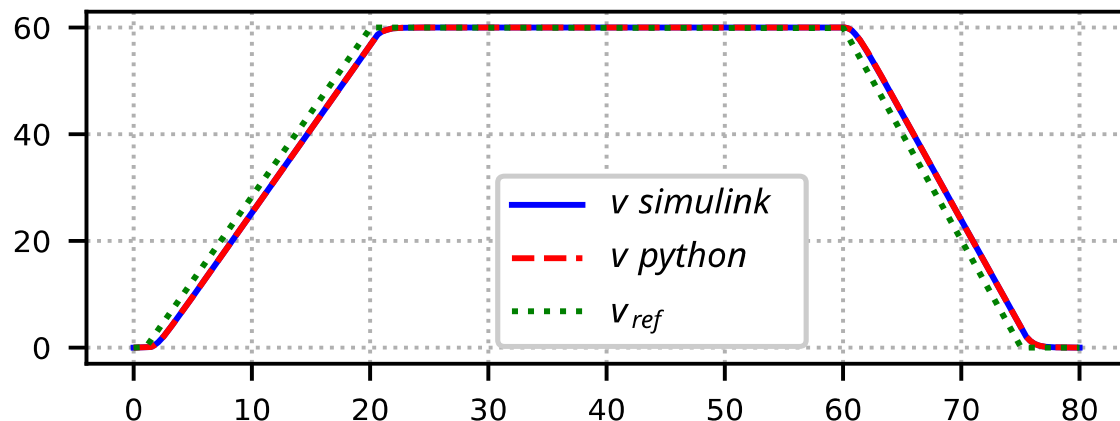
```
# =====
# Rectifier (compute DC current)
# =====
rectifier.Input(iL_abc, u_c_old, m_abc)
rectifier.Behavior()
i_dc = rectifier.Output()[1]

# =====
# Adaptation
# =====
adaptation.Input(i_dc, 4)
adaptation.Behavior()
i_dc_tot = adaptation.Output()

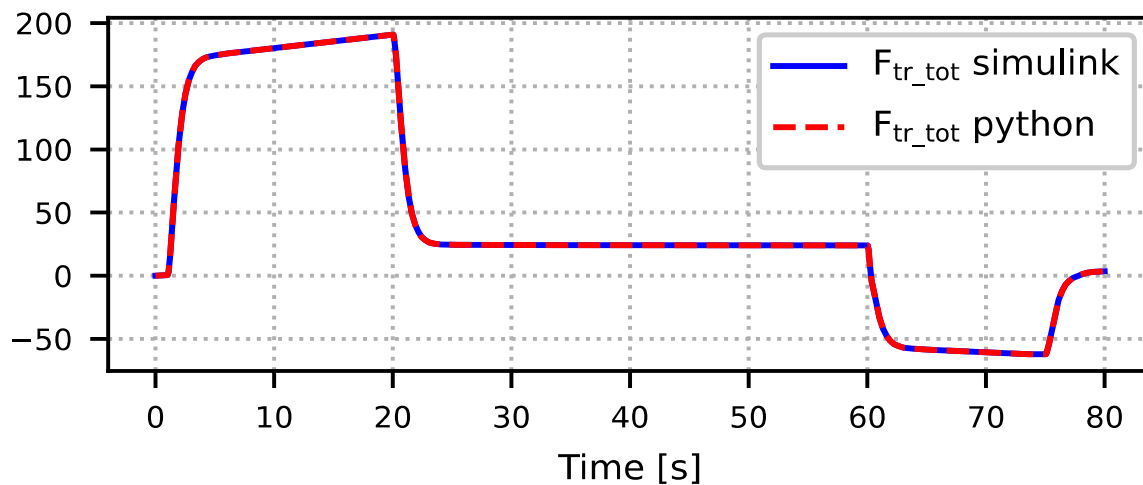
# =====
# Capacitor
# =====
capacitor.Input(i_dc_tot, i_train)
capacitor.Dynamic()
u_c = capacitor.Output() # DC-link voltage (update)
```

Comparative results based on Hanoi Metro Line 3

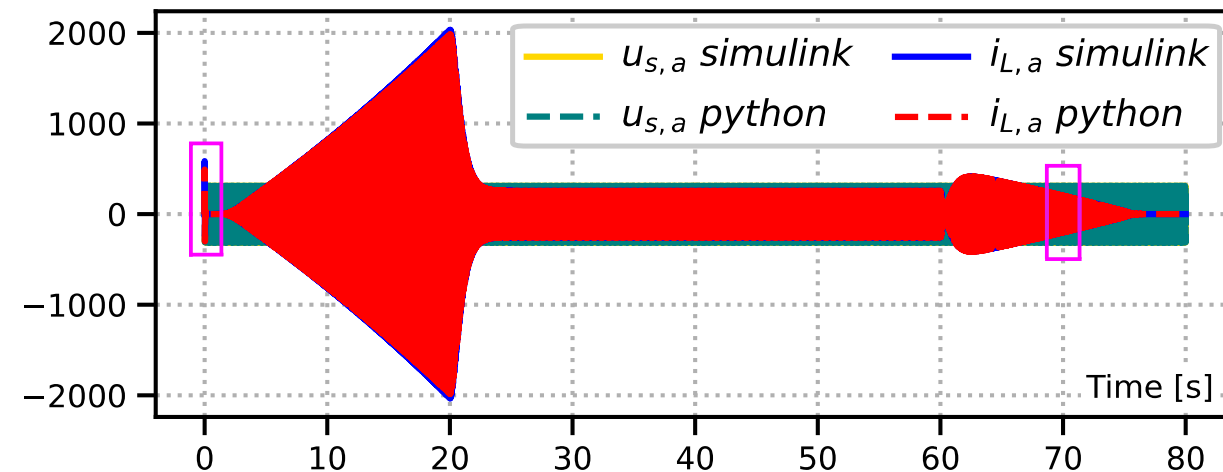
Speed of train [km/h]



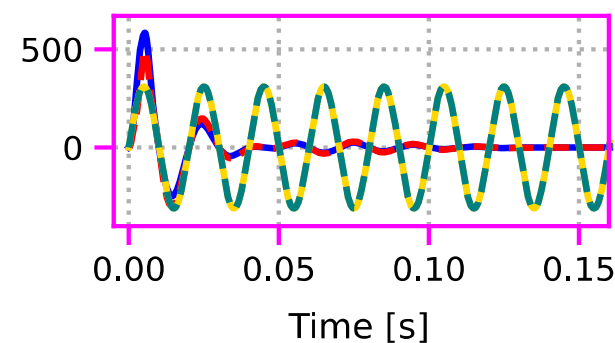
Total traction force [kN]



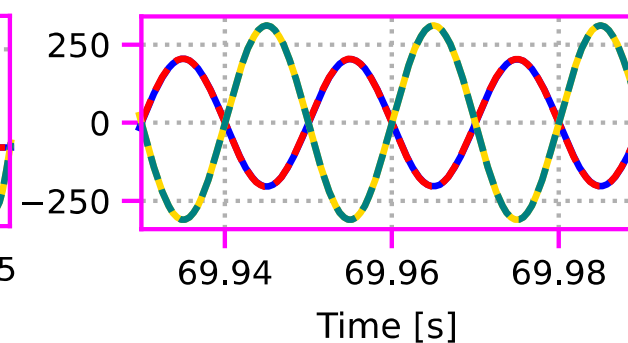
Phase-a grid voltage [V] and inductor current [A]



Zoom $u_{s,a}$ [V] & $i_{L,a}$ [A] 1



Zoom $u_{s,a}$ [V] & $i_{L,a}$ [A] 2





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CONCLUSIONS

- e-Mobility in Vietnam is developing with emphasize in service and public transportations
- Open-source simulation platform is possible based on EMR, demonstrated on subways
- Less dependence on commercial softwares to develop e-mobility studies

PERSPECTIVE & FUTURE WORK

- Extend to variety of e-transportations: car, bus, truck, ship
- Extend to real-time simulation for HIL and digital twin applications



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Thank you

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