Antonio Di Pasquale

Sustainable Mobility in Urban and Suburban Context

Tutor: Prof. **Mario Pagano**

Cycle: **XXXVI** Year: **Second**

Background

- M.Sc. in Electrical Engineering – Università degli Studi di Cassino e del Lazio Meridionale
- Research group: Power Systems (ING-IND/33)
- PhD start date: 01/11/2020 (Academic Year 2020-2021)
- Scholarship type: “UNINA”

Research field of interest

- Railway systems
  - Optimal Management strategies
- Power quality
  - Harmonic power flow
- Electric vehicle charging scheduling algorithm

Study and Training Activities

Scuola Nazionale Dottorandi di Elettrotecnica "Ferdinando Gasparini"

24th STAGE

(Napoli, 24-28 gennaio 2022)

Course of Identificazione e Controllo Ottimo (Master Degree Course)

(prof. F. Garofalo) A.A. 2021/22

ICHQP 2022

20th International Conference on Harmonics and Quality of Power

Naples, Italy, May 29th – June 1st 2022

- **Member of the Local Organizing Committee** of the 20th International Conference on Harmonics & Quality of Power (ICHQP).
- **Presenting author** of the paper "Voltage Quality of an AC Grid Supplying a Railway Power System with Energy Saving Strategy".

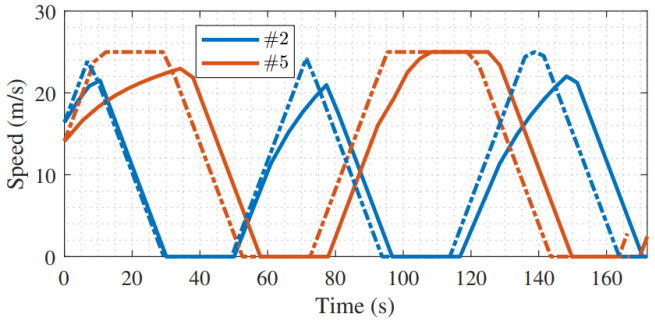
Operational Research: Mathematical Modelling, Methods and Software Tools for Optimization Problems (PhD course)

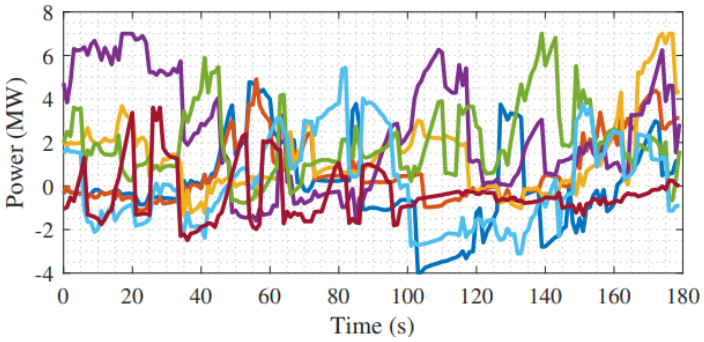
(prof. A. Masone) A.A. 2021/22

Optimal Management Strategies for Metro Railway System:
Problem Statement

The growing concerns about environmental issues draw attention to the need for improving the efficiency of DC metro railway systems. The reduction in the energy consumption of the latter passes through proper management strategies that aim to provide energy-saving through the optimal control of

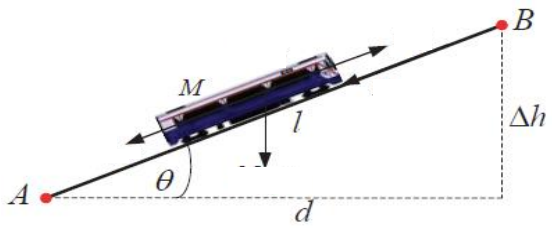
- trains acceleration/speed profiles
- electric power flow





Optimal Management Strategies for Metro Railway System:
Model

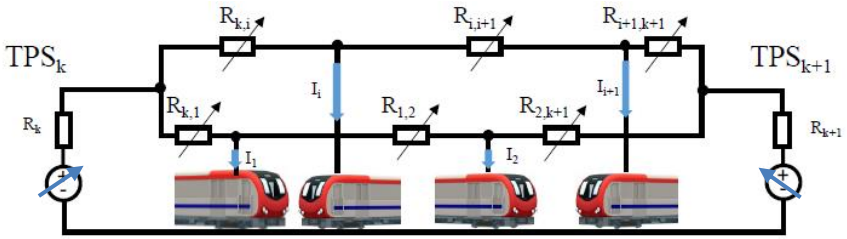
Mechanical Framework



$$M_{eq}\frac{dv(t)}{dt} = F(t) - R(s, v(t))$$

Train equivalent mass — **Traction Force** — **Resistance Force**

Electrical Framework



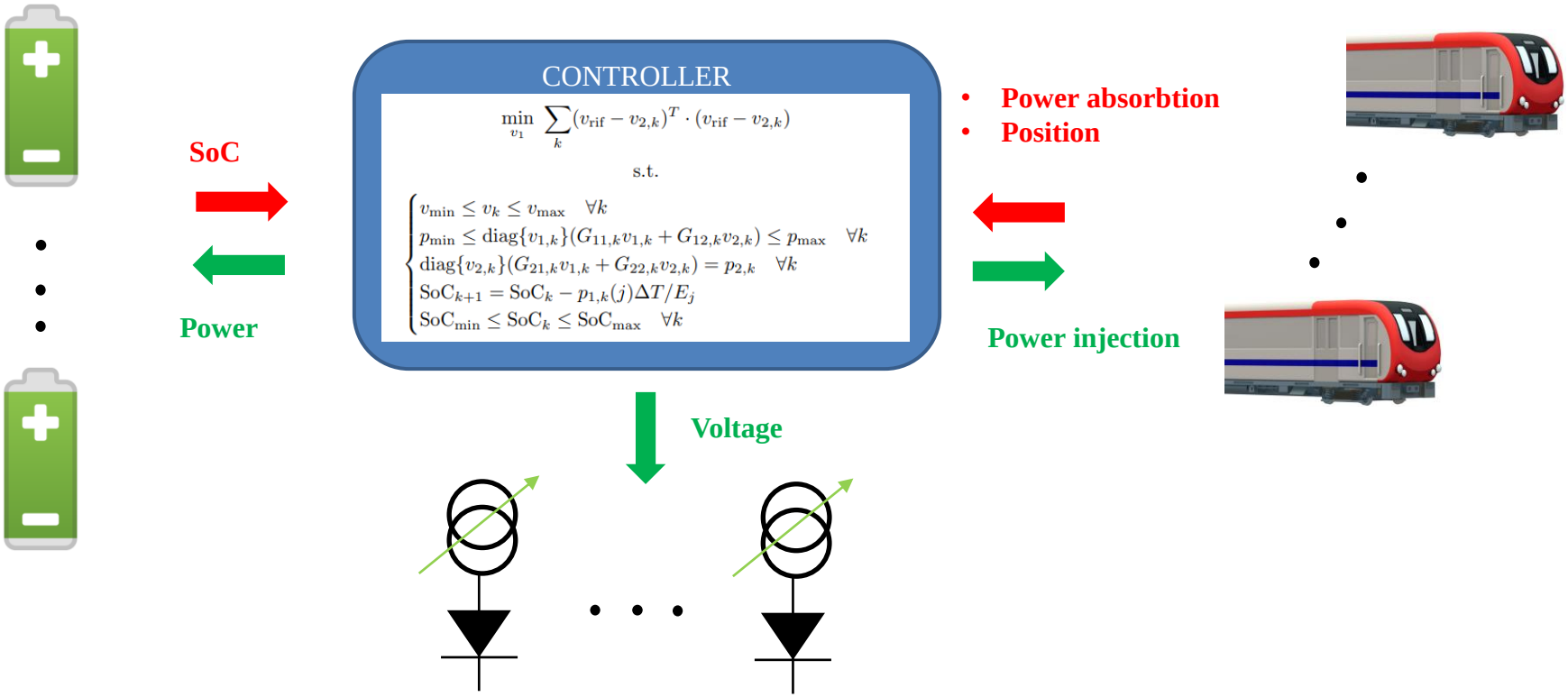
$$\text{diag}\left\{\begin{bmatrix} V_{\text{TPS}} \\ V_{\text{L}} \end{bmatrix}\right\} \cdot \left(\begin{bmatrix} G_1 \\ G_2 \end{bmatrix} \cdot \begin{bmatrix} V_{\text{TPS}} \\ V_{\text{L}} \end{bmatrix}\right) = \begin{bmatrix} P_{\text{TPS}} \\ P_{\text{L}} \end{bmatrix}$$

Nodal Voltages — **Conductance Matrix** — **Nodal Power**

$$\min_x f(x) \text{ such that } \begin{cases} c(x) \le 0 \\ ceq(x) = 0 \\ A \cdot x \le b \\ Aeq \cdot x = beq \\ lb \le x \le ub \end{cases}$$

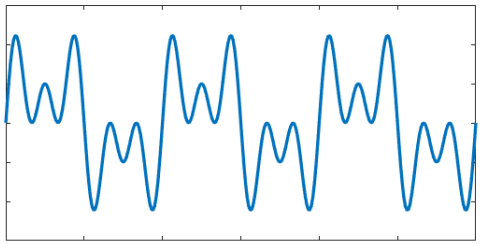
Optimal Management Strategies for Metro Railway System:

Approach



Problem Statement

Power distribution systems are experiencing a large-scale integration of distributed energy resources, such as renewable generators, energy storage systems, and modern loads, which are, typically, interfaced with the grid via power electronic converters. The presence of a large number of *Converter-Interfaced Distributed Energy Resources* (CIDERs) may compromise the stability of the system, in particular, the interaction of the latter with the grid can lead to unstable oscillations at harmonic frequencies.
Thus, the **Harmonic Power Flow (HPF)** represents a suitable tool to assess these phenomena and prevent them.

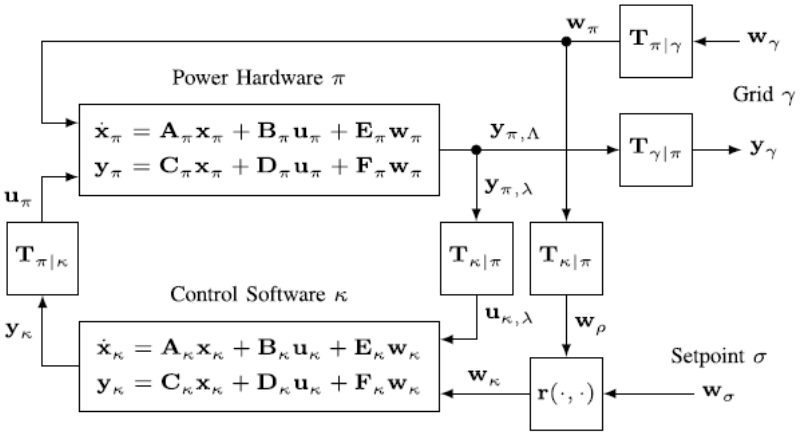


≈1-2 kHz

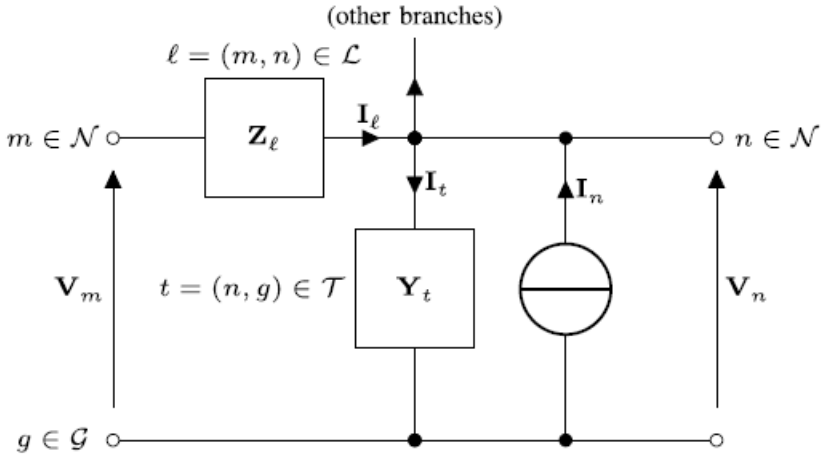
Harmonic Power-Flow Study of Polyphase Grids With Converter-Interfaced Distributed Energy Resources

Approach

CIDER



Grid



$$\begin{bmatrix}\hat{\mathbf{Y}}_\pi\\ \hat{\mathbf{Y}}_\kappa\end{bmatrix} = \begin{bmatrix}\hat{\mathbf{G}}_{\pi\pi} & \hat{\mathbf{G}}_{\pi\kappa}\\ \hat{\mathbf{G}}_{\kappa\pi} & \hat{\mathbf{G}}_{\kappa\kappa}\end{bmatrix}\begin{bmatrix}\hat{\mathbf{W}}_\pi\\ \hat{\mathbf{W}}_\kappa\end{bmatrix}$$

Cloosed-loop Transfer Function

$$\begin{bmatrix}\hat{\mathbf{V}}_\mathcal{S}\\ \hat{\mathbf{I}}_\mathcal{R}\end{bmatrix} = \begin{bmatrix}\hat{\mathbf{H}}_{\mathcal{S}\times\mathcal{S}} & \hat{\mathbf{H}}_{\mathcal{S}\times\mathcal{R}}\\ \hat{\mathbf{H}}_{\mathcal{R}\times\mathcal{S}} & \hat{\mathbf{H}}_{\mathcal{R}\times\mathcal{R}}\end{bmatrix}\begin{bmatrix}\hat{\mathbf{I}}_\mathcal{S}\\ \hat{\mathbf{V}}_\mathcal{R}\end{bmatrix}$$

Nodal Hybrid Equations

Does the solution exist?
Is it unique?

Just a Hint

The growing development of the electric vehicle (EV) market emphasizes the need for charging infrastructures technologically efficient and widespread throughout the territory. In this context, Ultra-Fast Charging Stations (UFCSs) represent one of the most interesting technological solutions thanks to their capability to charge EVs in less than ten minutes. These infrastructures are equipped with energy storage systems and are partially supplied by renewable energy resources.

Thus, **Charging Scheduling Algorithms** aim to optimally share the available resources among more EVs assigning suitable charging power profiles.

Year Three

Period Abroad

I started my research period abroad at Distributed Electrical Systems Laboratory (DESL) at **École Polytechnique Fédérale de Lausanne (EPFL)**, (Lausanne, Switzerland) on September 12th, 2022 (up to December 12th,2022).

Under the supervision of Prof. **Mario Paolone**, I am working on the HPF, in particular, the research activity aims at assessing the mathematical properties of the problem in order to provide conditions for the existence and uniqueness of the solution.

Year Three
What's Next?

- deepening the study of HPF, paying particular attention to electrical networks supplying railway systems to assess all the aspects concerning the power quality;

- studying and implementing optimal control strategies for railway systems to reduce the energy consumption of the entire electrical system (i.e., AC supplying grid and railway traction system)

- PhD Thesis Writing.

Products

[P1]	Di Pasquale, A., Fedele, E., Iannuzzi, D., & Pagano, M. (2022, May). Contribution of Wayside Energy Storage Systems to Short Circuit Currents in DC Railway Traction Power Systems. In *2022 International Power Electronics Conference (IPEC-Himeji 2022-ECCE Asia) (pp. 1101-1106). IEEE.* (**Published**).
[P2]	Fedele, E., Di Pasquale, A., Iannuzzi, D., & Pagano, M. (2022, May). Integration of Onboard Batteries and Supercapacitors Based on the Multi-Source Inverter for Light Rail Vehicles. *In 2022 International Power Electronics Conference (IPEC-Himeji 2022-ECCE Asia) (pp. 698-704). IEEE.* (**Published**).
[P3]	Andreotti, A., Di Pasquale, A., Mottola, F., Pagano, M., & Proto, D. (2022, May). Voltage Quality of an AC Grid Supplying a Railway Power System with Energy Saving Strategy. *In 2022 20th International Conference on Harmonics & Quality of Power (ICHQP) (pp. 1-6). IEEE.* (**Published**).
[P4]	Andreotti, A., Di Pasquale, A., Pagano, M., Ravichandran, N., & Volpe, F. (2022, June). An Optimal Centralized Control Strategy for Regenerative Braking Energy Flow Exchanges in DC Railway Traction Systems. *In 2022 International Symposium on Power Electronics, Electrical Drives, Automation and Motion (SPEEDAM) (pp. 436-441). IEEE.* (**Published**).

Products

[P5]	Andreotti, A., Di Pasquale, A., Pagano, M., Ravichandran, N., & Volpe, F. (2022, October). *Analysis of Lightning Transients in 2×25 kV 50 Hz Railway Traction System using EMTP. AEIT 2022 International Annual Conference.* (**Accepted**).
[P6]	Di Pasquale, A., Pagano, M., Petrarca, F., & Volpe, F. (2022, October). *Assessing a Health Index Algorithm for High Voltage Overhead Power Lines. AEIT 2022 International Annual Conference.* (**Accepted**).
[P7]	Attaianese, C., Di Pasquale, A., Fedele, E., Iannuzzi, D., Pagano, M., & Ribera, M. (2022, November). *Energy Efficiency Assessment for an Ultra-Fast Charging Station. 2021 IEEE Vehicle Power and Propulsion Conference (VPPC). IEEE, 2022.* (**Accepted**).
[P8]	Botte, M., D'Acierno, L., Di Pasquale, A., Mottola, F., & Pagano, M. (2022). Optimal Motion of a Rolling Stock Fleet under Traction Power System Constraints. *IEEE Transactions on Transportation Electrification.* (**Published**).

Thank you for the attention!