Richard Kayser MSc
„Friedrich List“ Faculty of Transport Sciences
Chair of Electric Railways

Using existing Tram Infrastructure for IMC

Current Research on Infrastructure and Synergies between Electric Transport Systems at the Chair of Electric Railways

31st Trolleybus Committee Meeting// Linz, 21.11.2019

Contents

Introduction

Prof. Dr.-Ing. Arnd Stephan
arnd.stephan@tu-dresden.de
www.ebahnen.de

Main focusses

Electric Vehicles and Propulsion

- Electric propulsion technologies
- Hybrid vehicles and alternative propulsion technologies
- Implementation of energy storage systems
- Vehicle board networks

Electric Power Supply / Networks

- Energy generation – Energy transmission – Network stability
- Catenary infrastructure systems and contact systems
- Electric safety and grounding
- Electromagnetic tolerance and influence
- Energy and power demand
- Life cycle costs and electrification worthiness

Research Methods, Tools, Laboratories

- Driving dynamics- and energy storage simulation
  (MATLAB-Simulink)
- Coupled system simulation Vehicle-Operation-Energy Grid
  (OpenTrack / OpenPowerNet)
- Genetic algorithms for multi-parameter-simulations
  (MATLAB, Toolboxes)
- FINite Element Simulation
  (ANSYS)
- Transient dynamic simulation with external models („Software in the loop“)
  (Power Factory, PLECS)
- Several LCC-Tools
  (from own development)
- Laboratory experimental equipment
  (contact wire wear, electric arc, pulley wheel tensioner …)
- Mobile experimental equipment
  (AMS – Arcing Monitoring System, CMS - Catenary Monitoring System, …)

Motivation

Why install trolley bus infrastructure on existing tram infrastructure?

1. Technical/Operational: Technical experience is invaluable
2. Economical: Electric infrastructure is expensive
3. Political: Targets for efficient public transport (i.e. EU Directive 2019/1161)
4. Components are nearly identical

Possibilities for common infrastructure

Can tram infrastructure be used commonly for trolley busses?

Yes.

Can we use existing tram infrastructure for trolley busses?

Yes and no.

DC Infrastructure Components

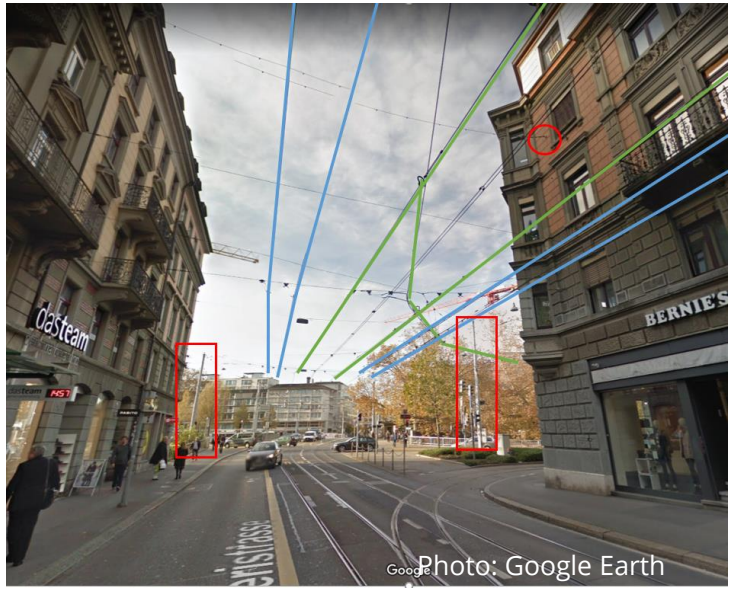
Exluding the overhead wire

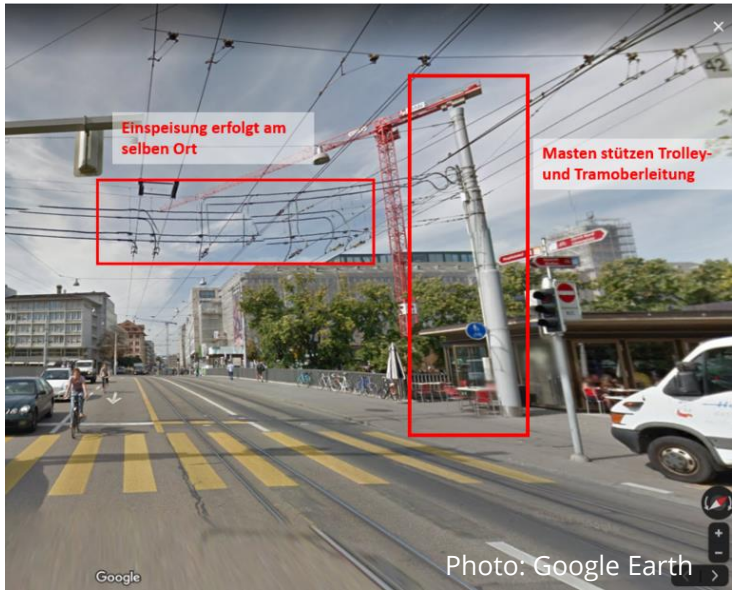
Catenary Infrastructure

- Masts
- Cross-Spans
- Wallhooks & anchors

Electric Infrastructure

- Substations / rectifiers / converters
- Feed-in cables
- Protection equipment





Schematic Overview of Electric DC Infrastructure

1 Electric Power station

2 AC Transport Grid

3 Medium AC Voltage Substation

4 DC Rectifier Substation

5 Feed-In Cable

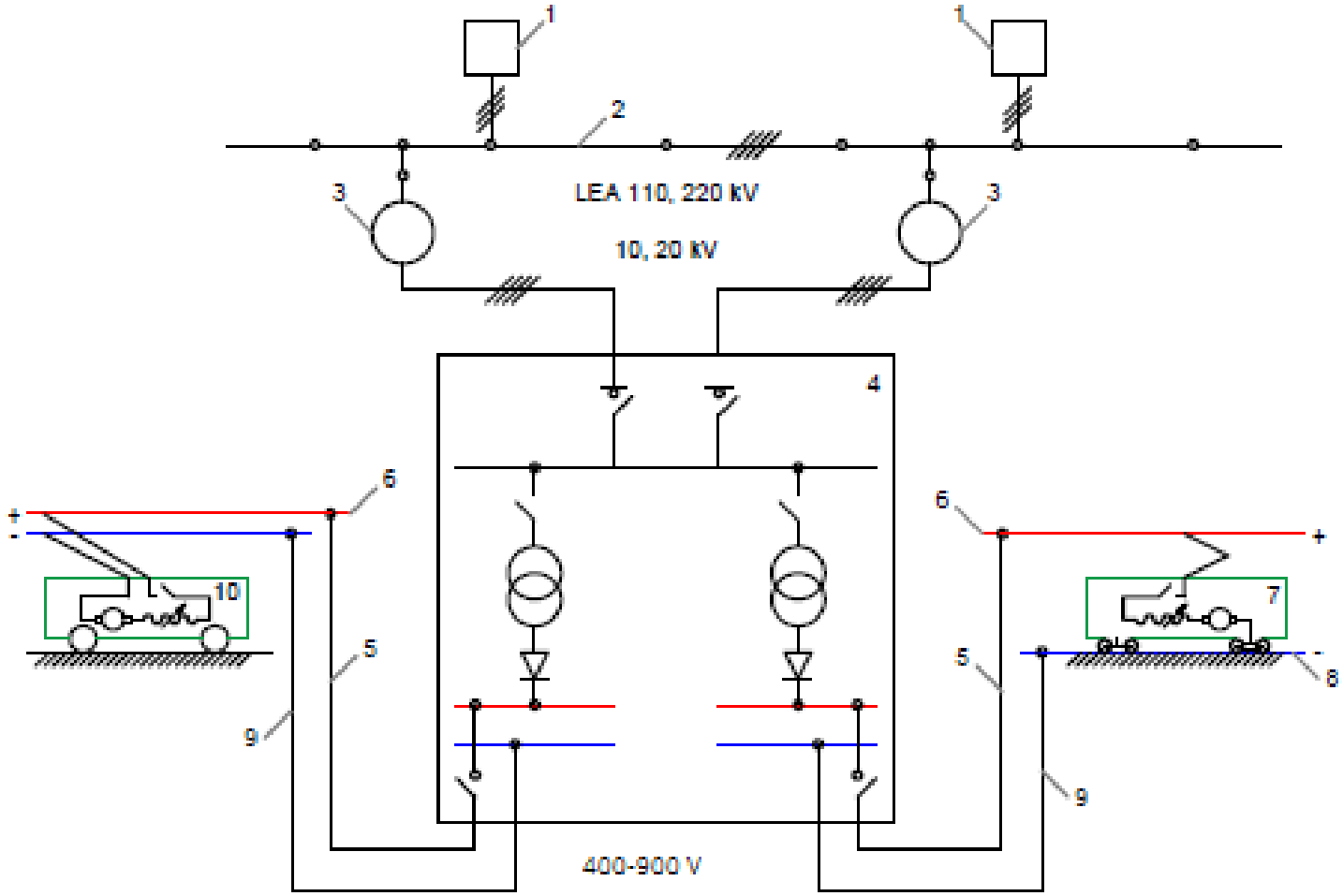
6 Overhead Contact Line

7 Tram

8 Rail

9 Return Circuit

10 Trolleybus



Adapted from M.-A. Mircescu, M.Sc. Thesis 2018

Assessing Electric Infrastructure

Benefits

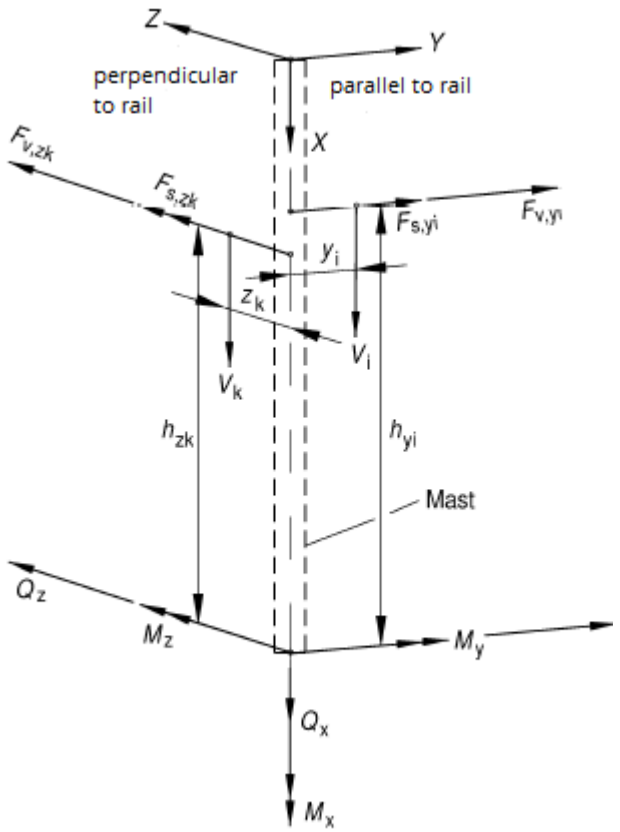
- Core electrical structure is the same
  - i.e. rectifier substations, insulated return circuits
- Rated voltages are the same
  - 600 / 750 V DC
- Scaling effects for substations
- Protection equipment and procedures are identical
- Load is higher but more steady with additional vehicles
- Energy efficiency is improved through more vehicles recuperating

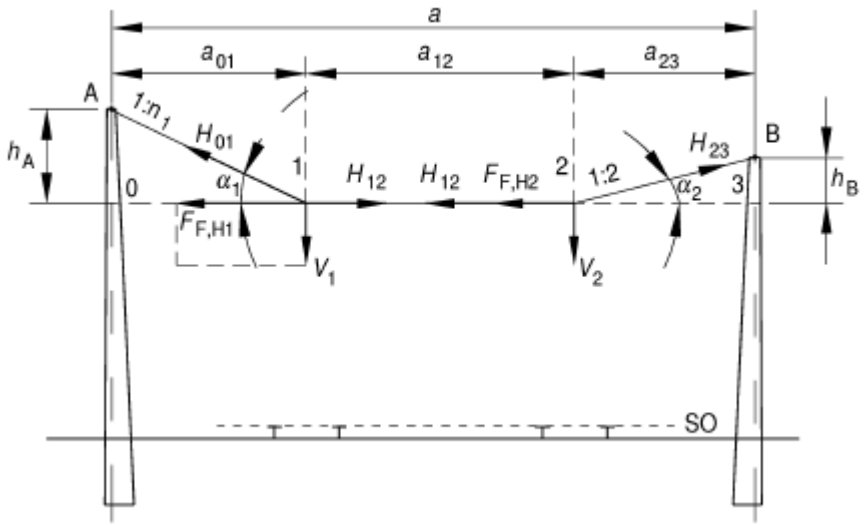
Challenges

- Voltage drop/ stability is more challinging in trolley networks due to small contact wires
- Earthing principles are different (earthing of tram return conductor is forbidden due to stray current protection)
- Combined substation arrangements require separate rectifiers and switch gears
- With an extension of the network, new switch gears and rectifiers are necessary
- Requires additional cables

Loads in Catenary Infrastructure

- Loads on contact wire, poles and cross span supports
  - Permanent loads: weight of supports (foundations)
  - Variable loads (wind and ice)
  - Accidental loads
  - Construction and maintenance loads
- Rating of components chosen based on loads
- Effects of additional trolley wires vary, based on installed components!





Source: Kiessling, Puschmann, Schmieder Schneider (2018) *„Contact Lines for Electric Railways“*

Assessing Catenary Infrastructure

Benefits

- Core components are the same and can be used commonly
- Existing power supply infrasture can be used twice (regarding high voltage grid connection)
- No additional sites & estates necessary
- The public acceptance of contact lines is higher in cities that already have a tram
- Catenary bound public transport systems define long term transport corridors (city planning and development)

Challenges

- In some cases extensive planning and recalculation of static properties required
- May require a reinforcement or replacement of catenary supports
- Constraints may occur as result of surrounding environment
- Visual impacts may reduce public acceptance in some areas

Considerations and Practical Implementations

Three scenarios

- Scenario A: New construction of tram and trolley bus systems in a city
- Scenario B: Replacing components at EoL and adding trolley bus infrastructure
- Scenario C: Adding trolley bus infrastructure to existing infrastructure

Scenario A

- Can take into account both systems, all infrastructure can be constructed for their purpose

Scenario B

- Substations can be replaced with larger ones, planning and assessment of masts and cross spans required but: placements and land is already available

Scenario C

- Requires extensive planning and building of new substations and likely purchasing of land

Conclusion

- With appropriate planning, trolley bus infrastructure can be installed on tram infrastructure
- Refitting substations may be critical and protection requirements have be considered in detail
- Catenary infrastructure must be designed to withstand loads from both systems
- A strategy for the refitting of lines is vital
- Benefits include: Higher degree of utilization, existing technical experience, identical components
- IMC lines add even higher degree of utilization
- Tram and trolleys are very compatible to one another

Thank you!

Richard Kayser
Scientific Assistant
Chair of Electric Railways
TU Dresden
+49-(0)351-463-36737
Richard.kayser@tu-dresden.de

Relevant Norms and Literature

EN 50163: Railway applications - Supply voltages of traction systems

EN 50119: Railway applications – Fixed installations – Electric traction overhead contact lines

EN 50122: Railway applications – Fixed installations – Electrical Safety, earthing and the return circuit

EN 50125-2: Railway applications – Environmental conditions for equipment

IEC 60826: Design criteria of overhead transmission lines

Kiessling, Puschmann, Schmieder, Schneider (2018); *Contact Lines for Electric Railways – Planning, Design, Implementation, Maintenance;* Publicis Publishing; Third Edition