trolley 2.0 final conference - Session II: Smart trolley grids

Common electric infrastructure for tramway and trolleybus systems

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Rail Power Systems

Structure

› Electrical supply infrastructure
for tramways & trolleybuses

» Demands on infrastructure

» One infrastructure for both

» Extending an existing infrastructure

» Charging concepts and market relevance

Electrical supply infrastructure

Demands from tramway and trolleybus

- Tramway
  - Mainly double-sided feeding
  - Two-pole - return via rail
    - Rail = low resistance conductor
    - (Low impedance) insulated from earth
    - Ground level
  - Single-pole breaking
    - DC high-speed circuit breaker (HSCB)
  - Protection
    - Overcurrent
    - dI/dt
    - …..
- Trolleybus
  - Single-sided feeding
  - Two-pole - return by 2nd contact line
    - Same resistance for both poles
    - Fully insulated
    - Contact wire height
  - Two-pole – breaking (& isolation)
    - HSCB (+ Return disconnector)
  - Protection
    - As tramway system
    - + Insulation monitoring

Normative background

EN 50122-1:2011 5.6.3.4

Trolleybus power supply connected to the power supply of a tramway

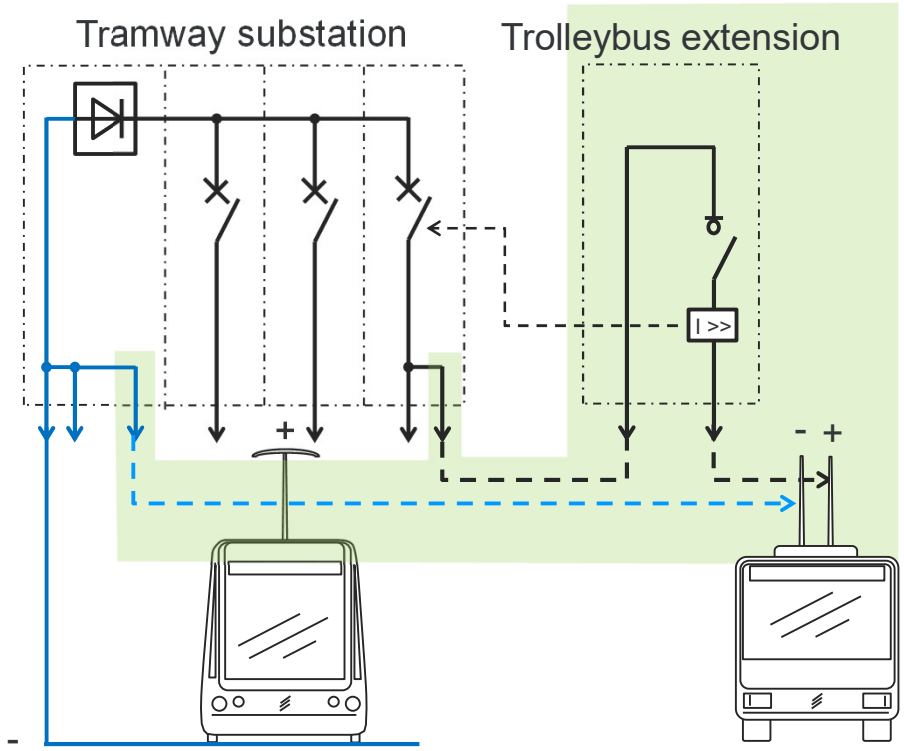
In case of a common traction power supply system for a trolleybus system and a tramway system, the following conditions shall be fulfilled:

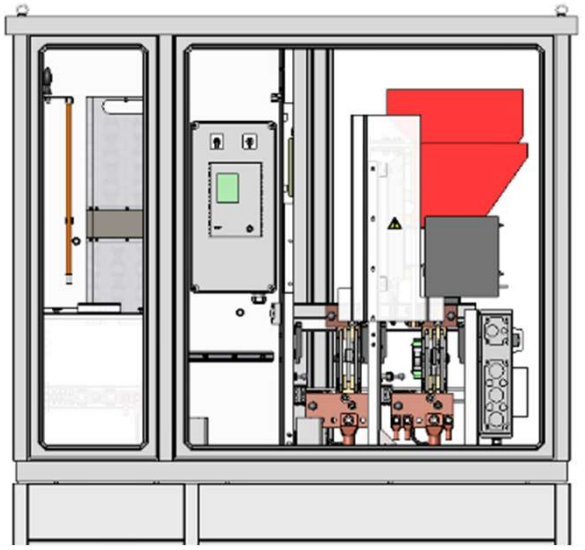
- one contact wire trolleybus system shall be connected without any disconnection to the return circuit of the tramway system;
- in case a switching device is installed in the wire connected with the tramway return circuit, another switch shall be installed in the other wire, and the switching device shall be interlocked so that it cannot be opened before the supply switch is open;
- the trolleybus return circuit shall be connected at least once to the return circuit of the tramway system.

Tramway substation – adaptions required

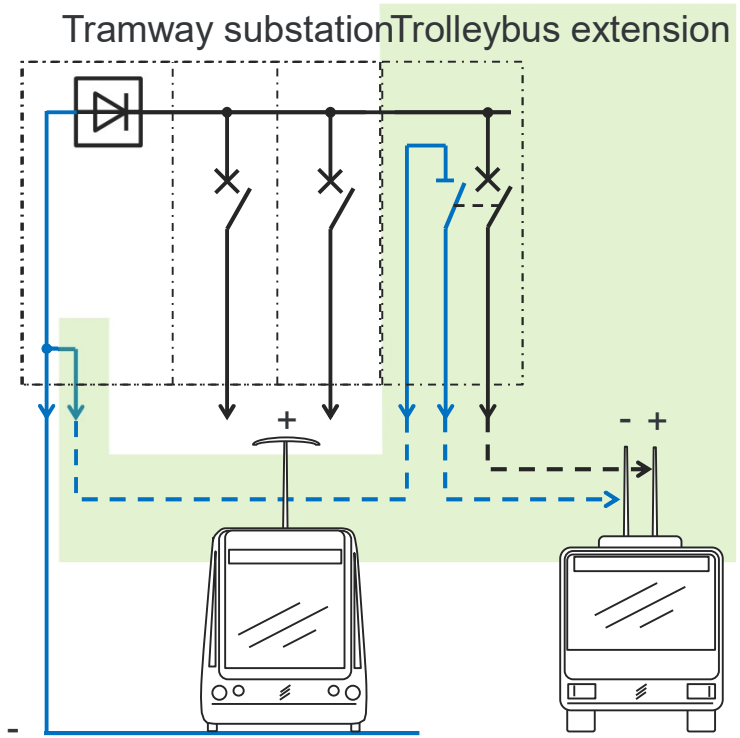
- Feeder voltage (positive)
  - Separate HSCB panel with direct connection to substations main busbar
  - Pick-up from existing line feeder
    - Switch disconnector for normal operation
    - Trip of line feeder HSCB in case of faults
- Return feeder voltage (negative)
  - Direct connection to return current busbar
  - Return current disconnector
    - In parallel to HSCB or Switch disconnector
    - Interlocking to ensure disconnector to be closed first/opened last

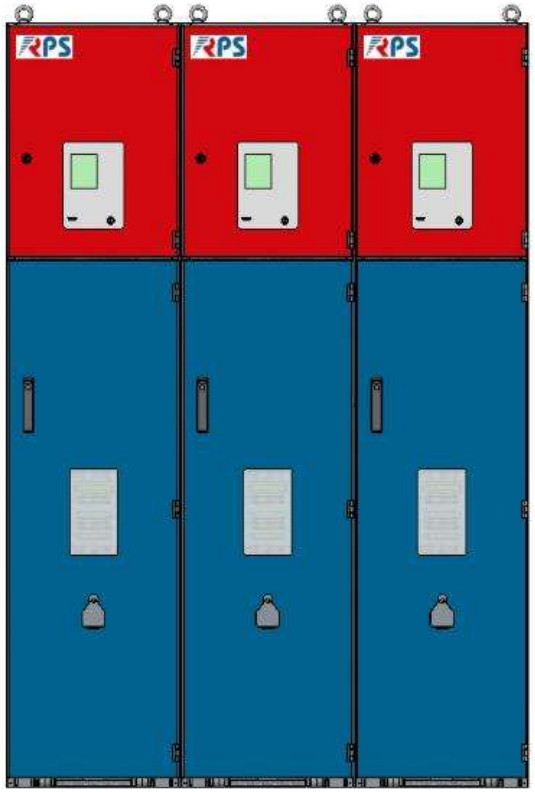
Tramway substation – external extension





Tramway substation – integrated extension



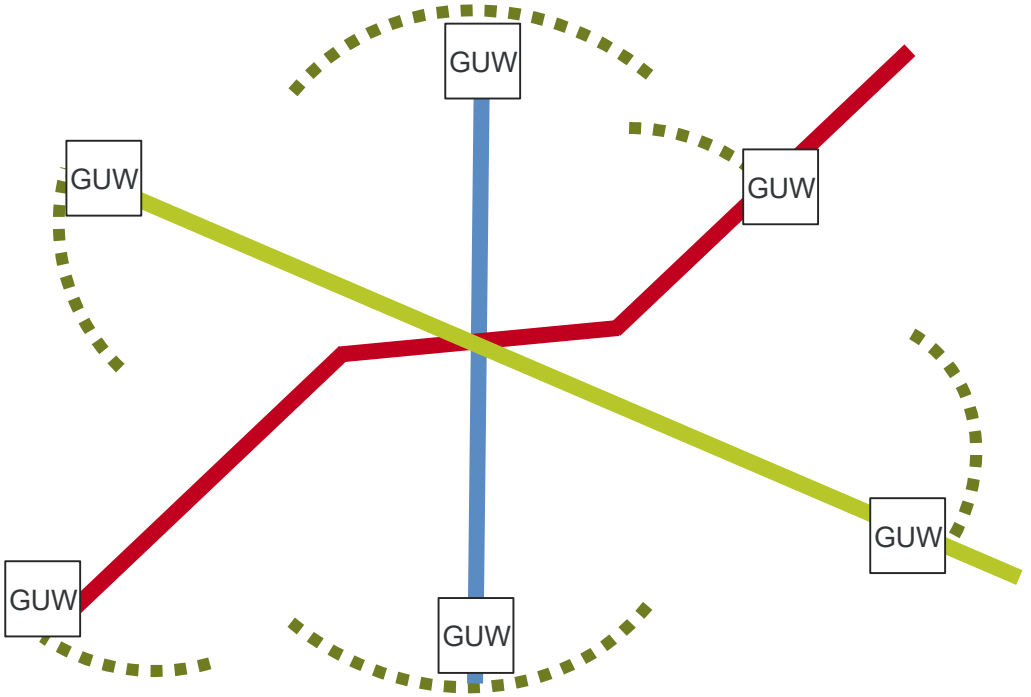


Extending a tramway network

Tramway network

IMC bus line under
trolleybus overhead contact line

GUW Rectifier substation



Example – Task for simulation

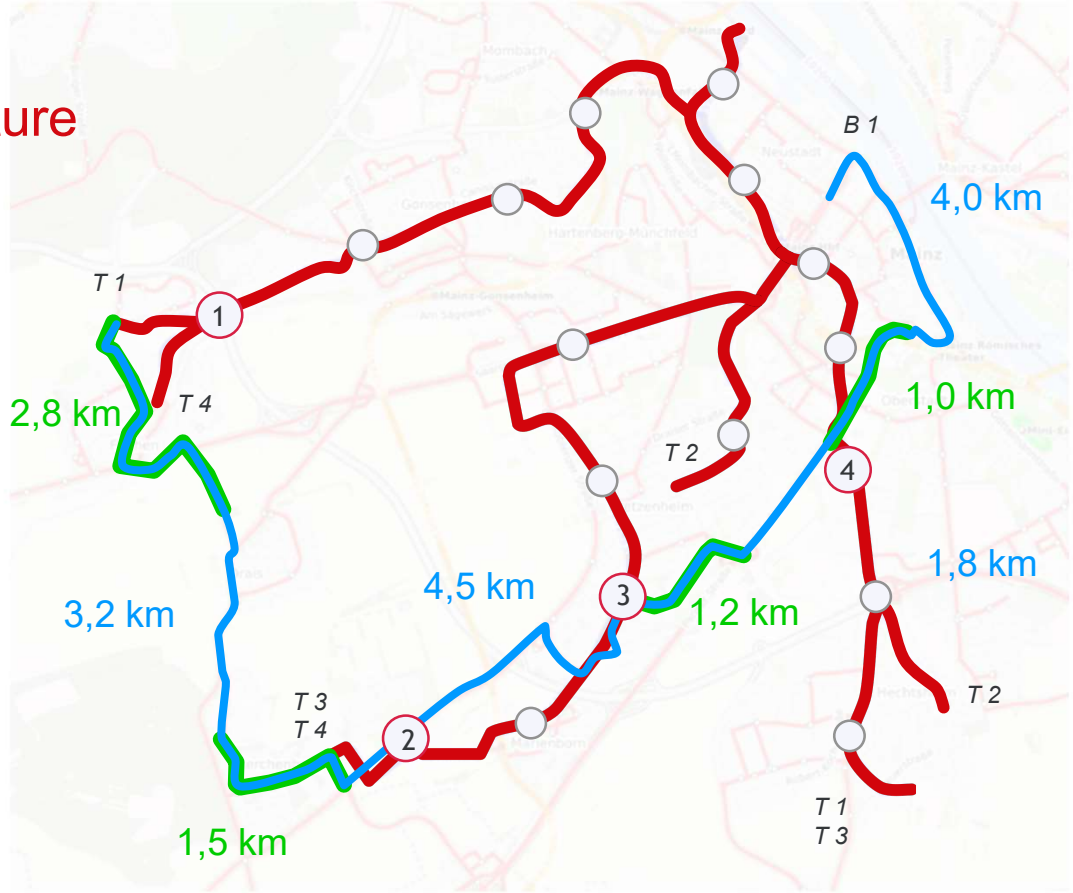
Supply of a new trolleybus system by an existing infrastructure

- Existing tramway system
  - Route length 32 km
  - Radial structure
  - Substations 16
  - 4 lines, cycle time 10/15 min
- Tramway
  - Type Variotramway
  - 66 t total mass
  - Maximum current 1000 A
- New bus route
  - Route length 20 km
  - Annular line
  - 1 line, cycle time 15 min
- Bus
  - 18 m IMC®-Bus
  - 27 t total mass
  - Maximum current 600 A

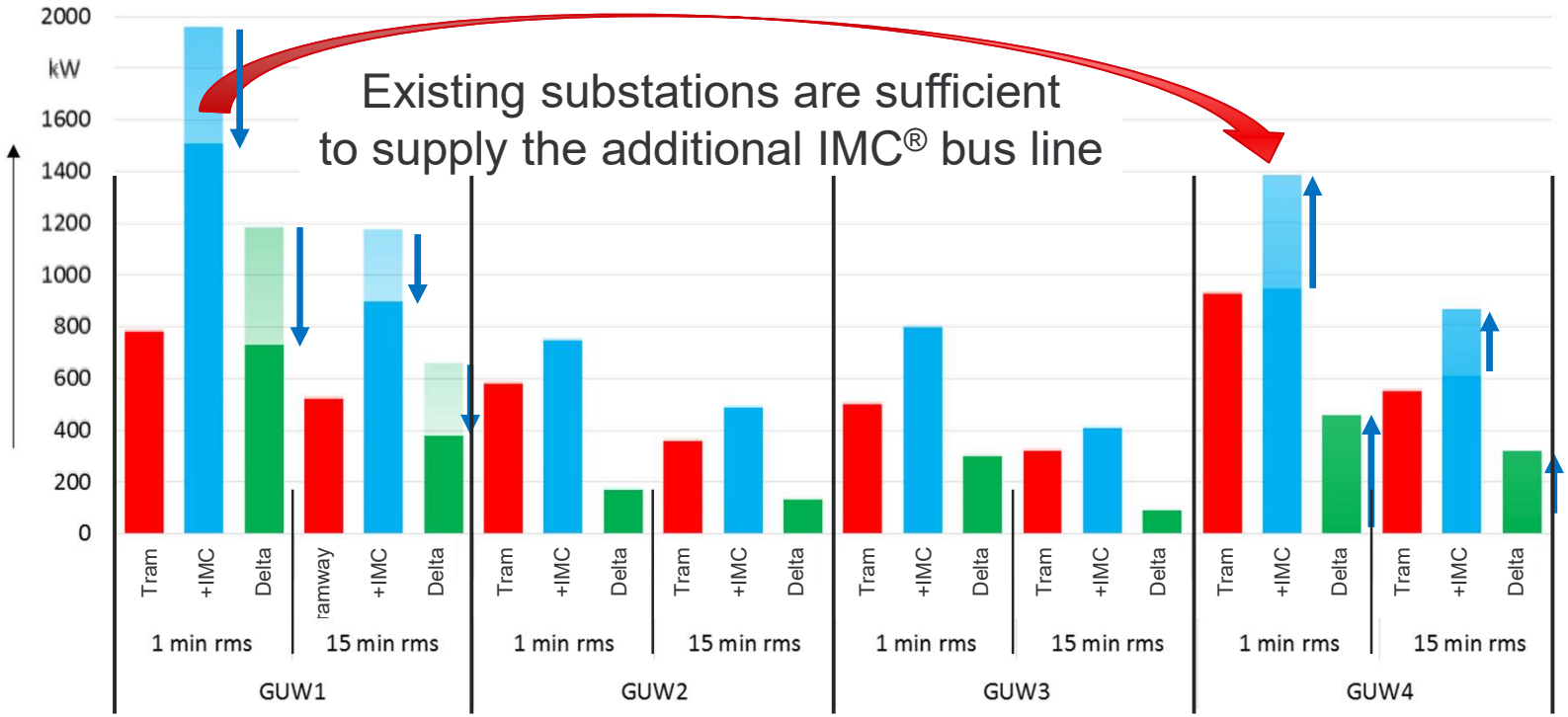
Example – Network structure

- Tramway network
- IMC®-Bus-route
- Trolleybus catenary
- Rectifier substation

Overhead contact line needed for around 32 % of IMC®-Bus-route



Example: Resulting power demand and optimisation



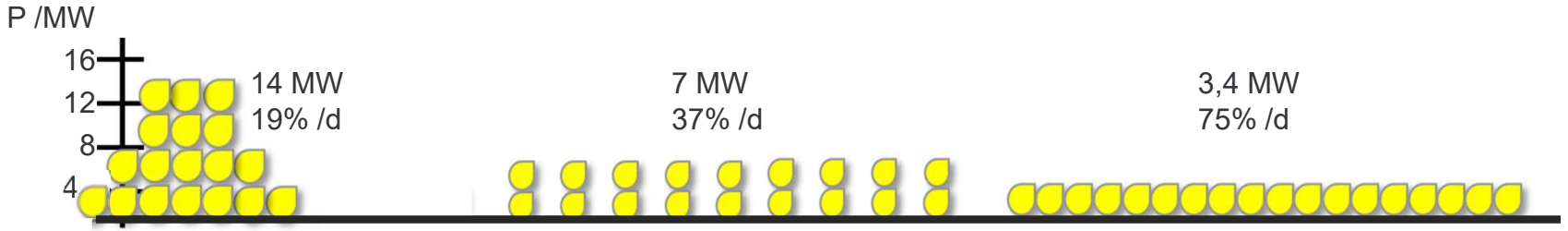
Competing charging strategies?

Overnight Charging (ONC) / Opportunity Charging (ONC plus) / In Motion Charging (IMC®)

- ONC infrastructure
  - costs increase proportionally to the daily kilometers
    - Number of buses ≈ number of charging points
- IMC® infrastructure
  - costs increase proportionally to the length of the electrified network
    - Lines using same network
- Conventional battery buses have lower limits of charging voltage
  - Not compatible with the DC traction power supply

- Differentiated view on routes beneficial – length, parallel routes, topography
- IMC® buses also allow use of ONC and ONC plus

Power demand and use of infrastructure



In Motion

Opportunity

Overnight

KIEPE ELECTRIC

RPS

Trolleybus overhead contact line

- Cost reduction through the parallel use of supporting structures
- Additional benefits for IMC®
  - Simplified construction
    - No crossings, no turnouts
    - Not perceived as a disruptive element in inner city areas
- No extra floor space required different to charging stations

Market relevance – Example Germany

- Cities with tramway systems
  - 61 cities
  - 22,7 million residents
  - 3 600 km electrified lines (interurban routes not included)
    - In average 5 800 residents/km
    - ca. 1 200 Rectifier substations

- Criteria for a trolleybus potential
  - ≥ 50 000 residents and
  - ≥ 15 km of tramway route
    - ≥ 3 500 residents/km$_{\text{existing route}}$

- Increased potential with
  - Reduced length of new overhead contact lines
  - use of existing substations

→ 44 cities in Germany
↳ 42 with trolleybus operation in the past

Happy to answer your questions

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