Järnvägsgruppen

Invitation to KTH Railway Group seminar (+lunch)

When: Wednesday 30th November 2016 at 10.15-12.50

Where: KTH, Teknikringen 8, ground floor, Vehicle Engineering Laboratory

10.15-10.30	Coffee etc
10.30-10.35	Welcome
10.35-11.00	Therese Arvidsson, Raid Karoumi and Costin Pacoste: *Vertical wheel-rail forces for bridges with slab track - Comparison with the Eurocode acceleration criteria* (SB14)
11.05-11.30	Luca Bessegato, Staffan Norrga, Stefan Östlund, Lennart Harnefors and Hans-Peter Nee: *Modelling and control of AC/AC modular multilevel converters* (EP7)
11.30-11.45	Information from the Director
11.45-11.55	Break
11.55-12.20	Zhendong Liu and Sebastian Stichel: *New concept for higher speed on existing catenary system – Auxiliary pantograph operation*
12.25-12.50	Mats Berg, Sebastian Stichel and Carlos Casanueva: *Universal Cost Model for innovative vehicle design*
12.50	Lunch

For participation in the seminar and lunch, please inform Mats Berg at mabe@kth.se by 25 November.

Welcome!

Sebastian Stichel and Mats Berg
2016-11-18

Vertical wheel–rail forces for bridges with slab track: comparison with the Eurocode acceleration criteria

Project leader and main supervisor: Raid Karoumi, Co-supervisor: Costin Pacoste, PhD-student Therese Arvidsson, therese.arvidsson@byv.kth.se

In the design phase for railway bridges, a dynamic assessment must generally be conducted for bridges with a design speed greater than 200 km/h. Most often, the decisive criterion is the limit on the vertical bridge deck acceleration. The maximum allowed bridge deck acceleration is 3.5 m/s² for bridges with ballasted track and 5.0 m/s² for (non-ballasted) slab track. The background to the bridge deck acceleration criterion for ballasted bridges is the fact that ballast has been observed to grow unstable at high ballast accelerations. The limit (5 m/s²) for bridges with slab track, on the other hand, has no direct physical interpretation and is not necessarily a good measure of the running safety of trains over these bridges. Instead, we want to look at the running stability measures that can be derived from the study of vertical wheel-rail forces.

A 2D finite element model in Matlab is used including the vehicle, slab track and bridge (see figure 1). A track irregularity is included in the model to consider the vertical deviation of the track from its ideal geometry. The contact between the vehicle and the rail is modelled as either rigid or using a linear Hertzian spring. The wheel-rail force can be obtained from the model as the vehicle run over the track-bridge-system. From the wheel-rail force we can obtain one measure of running safety: the vertical wheel unloading factor $\Delta Q/Q_0$ (where Q_0 is the static wheel-rail force and ΔQ is the deviation from the static wheel-rail force). To evaluate the Eurocode limit for vertical bridge deck acceleration we will look at the amount of wheel unloading for bridge deck accelerations at the design limit (5 m/s²). An example of wheel-rail forces for a train running over a 20 m slab bridge is shown in figure 2.

Questions to be discussed (input from the audience):

1. Which limit criterion should we use for the vertical wheel-rail force?
2. Rigid contact or Linearized Hertzian spring contact?

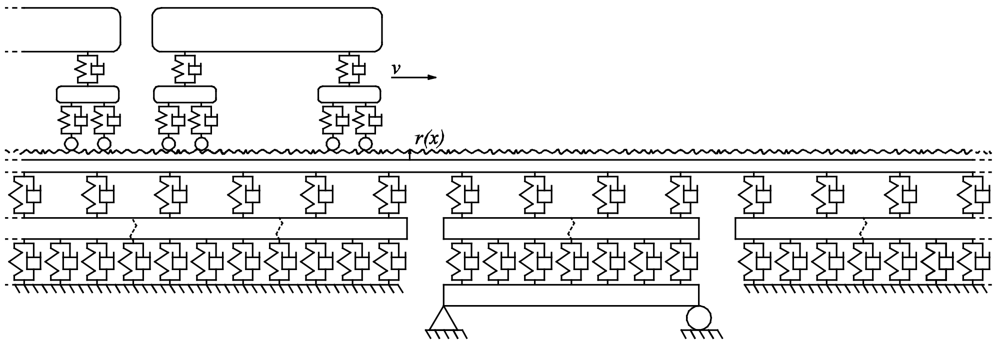

Figure 1. 2D train-track-bridge model for bridges with slab track.

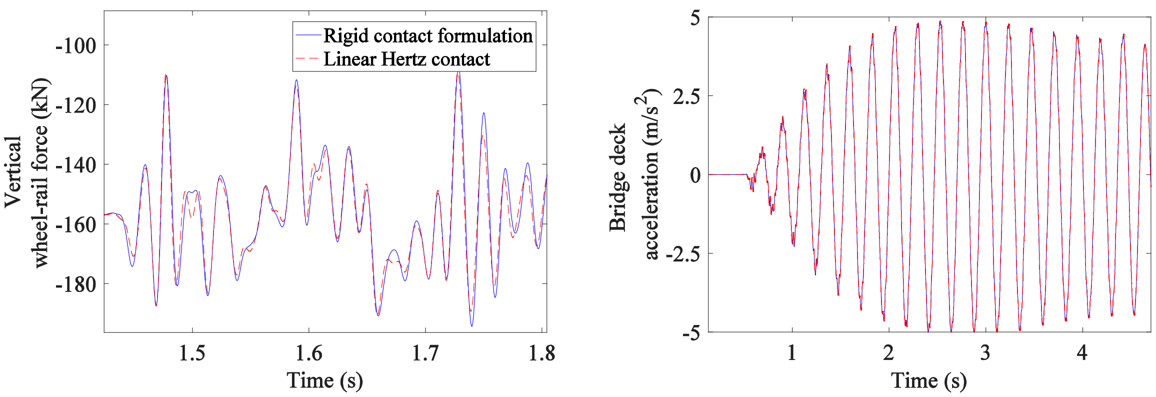

Figure 2. Wheel-rail contact force (left) and bridge deck acceleration (right).

Modeling and Control of AC/AC Modular Multilevel Converters

Main supervisor: Stefan Östlund, Co-supervisors: Staffan Norrga, Lennart Harnefors, and Hans-Peter Nee
PhD-student: Luca Bessegato

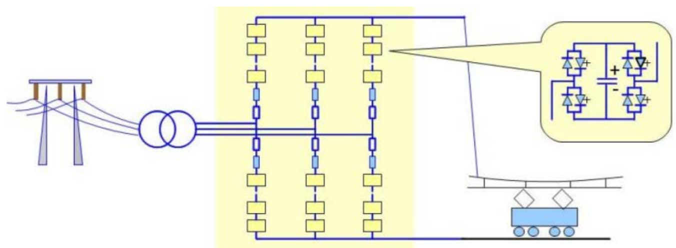

Figure 1: modular multilevel converter for railway application

The latest stage in the development of converter stations for railway feeding is the introduction of modular multilevel converters (MMCs), which have earlier been introduced very successfully for power grid applications such as HVDC and FACTS. For railway feeding purposes converters with direct ac/ac conversion capability will probably be used, and these will be the main topic of study in the project. These converters offer many benefits such as reduced losses, and increased modularity, which can improve reliability through redundancy. Also, the possibility to design the converter with high-voltage output so that it can be connected to the catenary network without a transformer reduces cost and losses. However, these converters have complex and highly non-linear dynamics which present challenges for their design, control and operation. This can lead to uncontrolled resonances and other unwanted phenomena.

Studies of ac/ac modular multilevel converters have not been extensively reported in literature and there are likely great opportunities for improvement. In this project, models describing the core behavior of the converter are developed in order to provide good insight into the converter behavior and a solid foundation for further research. A dialogue with Trafikverket converter specialists drives the research into topics of practical interest for railway application, such as converter-grid interaction. The current research focus is on impedance modeling of the converter, which is useful for understanding grid-converter interaction and design of the system. A low-power prototype converter, currently under construction, will experimentally verify the results of this project.

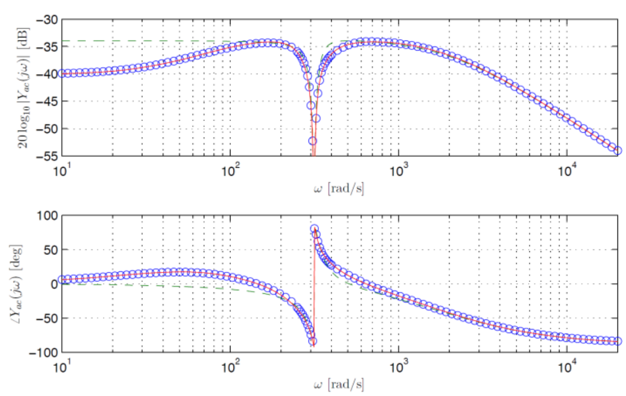

Figure 2: ac/dc MMC input admittance

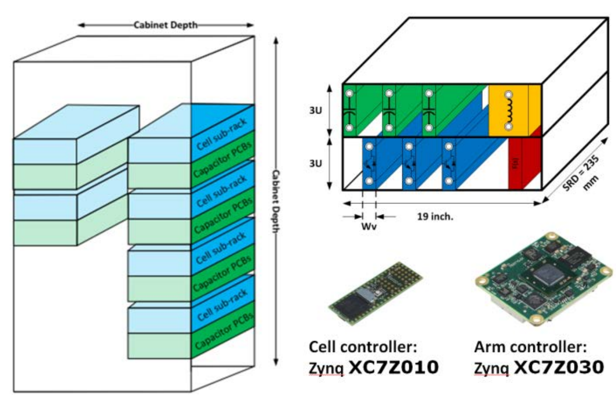

Figure 3: low-power prototype design

New Concept for Higher Speed on Existing Catenary System: Auxiliary Pantograph Operation

Zhendong Liu [a] and Sebastian Stichel [a]

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Abstract

The main railway lines in Sweden have been electrified since the beginning of the 20th century, and there have been many types of catenary systems developed by now. Due to the structure of the catenary, stiffness variations and wave propagation in the catenary system can cause high dynamic loads in the contact between pantograph and catenary at high operating speeds, which undermines current collecting quality, shortens the life cycle of the infrastructure and increases the maintenance cost. In order to increase the operational speed on existing catenary systems, especially on soft catenary systems, technical upgrading is usually necessary to limit the force variation within an acceptable range. According to previous studies, possible technical modifications are: tension force increase on the catenary system, catenary design with stitch wire, auxiliary wire and mid-span sag, pan-head mass reduction, and actively-controlled pantograph. However, the implementation of most of these measures does not only need large investments but also long out-of-service time. Therefore, it is desirable to explore a more practical and cost-saving method to achieve higher operational speed on existing lines.

With the help of a 3D pantograph-catenary finite element (FE) model, a parametric study on two-pantograph operation at short spacing distances is carried out. Results show that although the leading pantograph suffers from deterioration of dynamic performance, the trailing pantograph achieves a better dynamic behaviour by using a proper spacing distance between pantographs at some certain speeds. The results also show that the two positive effects still remain even with some system parameter deviations. To take advantage of the effects and to avoid the additional wear caused by poor dynamic performance on the leading pantograph, it is suggested to use the leading pantograph as an auxiliary pantograph which does not conduct any electric current. To help implementation of auxiliary pantograph operation, optimized uplift force on the auxiliary pantograph is proposed, which can not only reduce the mechanical wear caused by the auxiliary pantograph but also further improve the dynamic performance. In addition, results show that the system does not become very sensitive to small deviations of some system parameters. Meanwhile, to avoid some unfavourable working conditions and to pass through special sections, it is possible to lower or raise the auxiliary pantograph on purpose during operation to ensure safe operation.

In this way, without large modifications necessary to be made on the existing catenary system, the operational speed can be increased by 30%, and the same dynamic behavior existing at current maximum operational speed of the systems can be sustained. Therefore, this solution gives us a new option to upgrade the railway pantograph-catenary system, in which the traveling time for passengers and the infrastructure investment for railway operators can be significantly reduced. Correspondingly, the large amount of green gas emissions and the solid waste due to the system upgrading can significantly be limited.

Keywords: existing catenary system, speed increase, auxiliary pantograph, optimized uplift force, pantograph raising/lowering, system sensitivity.

Universal Cost Model for innovative vehicle design

Mats Berg, Sebastian Stichel and Carlos Casanueva

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Abstract

In the development of enhanced rail vehicle designs the added benefits are sometimes difficult to motivate from an economical perspective. This is often due to a higher initial vehicle cost while the benefits are spread over the entire vehicle life and are more difficult to quantify. This calls for a Life Cycle Cost approach, but which still seems to be hard to adopt in many rail organisations.

In the ongoing European project Roll2Rail, a pre-project to the extensive research programme Shift2Rail, this issue is taken on focussing on innovative bogie designs (Work Package 4). Partners in WP4 mainly represent vehicle manufacturers and vehicle operators, but also infrastructure managers like Trafikverket and academic organisations like KTH. WP4 is led by Bombardier Transportation.

To balance or preferably exceed the higher initial cost, and associated capital cost, four types of other costs are studied in detail: vehicle maintenance cost and the vehicle operational costs for energy, noise and track access. For separated railways the track access cost for a vehicle operator originates from a charge imposed by the infrastructure manager. Unfortunately this charge seldom acknowledges improved vehicles designs that offer reduced track maintenance and external noise.

The WP4 work is setting up a framework, a so-called Universal Cost Model, where the above cost components are included, with the aim to simplify LCC calculations and support innovative vehicle designs. A challenge is to connect technical improvements and results into economical quantities.

The seminar presentation will provide further insight into this work and welcomes further input to the ongoing efforts in Roll2Rail WP4.