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System design with Sicat Dynamic

Simulation of the interaction between overhead contact line and pantograph

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The use of the simulation software Sicat® Dynamic for the configuration of catenary systems for mass transit and main-line railways and for the approval of rolling stock in conjunction with our extensive system know-how allows reliable predictions for the interaction of overhead contact line equipment with pantographs.

Features

- Flexible and accurate representation of all components of the overhead contact line
- Fast and accurate calculations by the use of computers with high performance
- Provides statements which reliably match with the measurements of the current collection quality
- Meets the requirements of EN 50318 for the validation of simulation systems for the dynamic interaction between pantograph and overhead contact line

Language of reports

By default, reports can be generated in German and in English. Further languages for reports are possible.

Applications

In the development and conformity assessment of overhead contact line systems the simulation of the interaction of the contact line with the pantograph is indispensable.

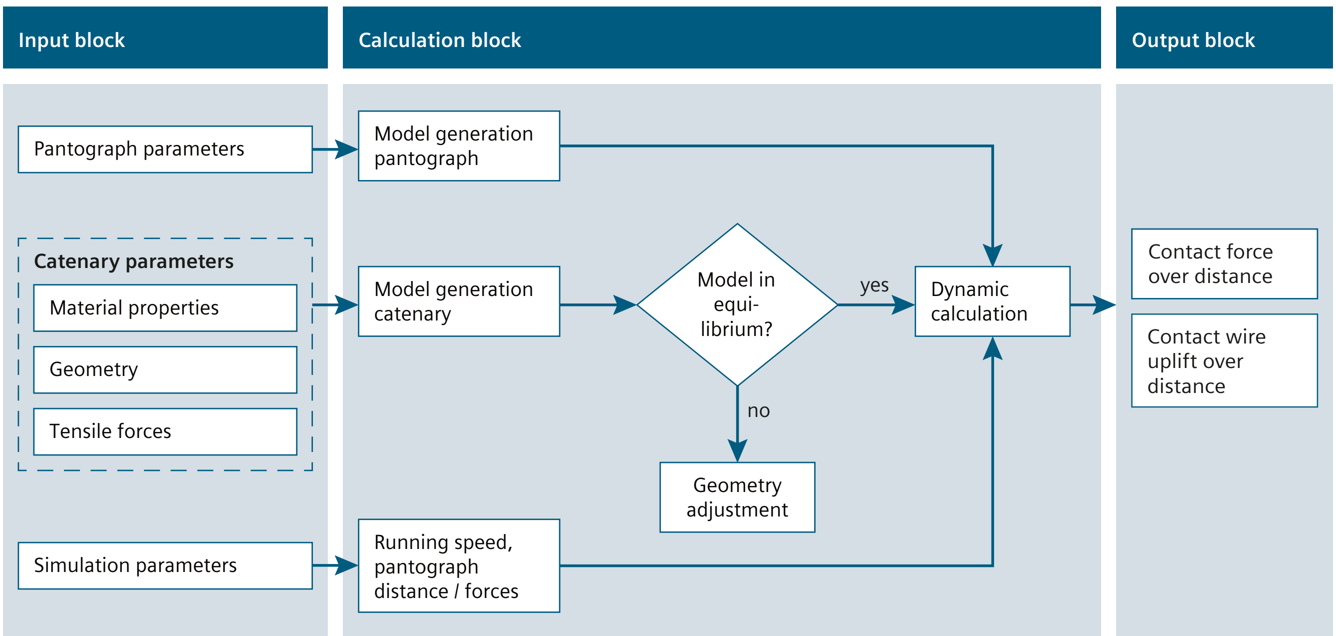
The use of Sicat Dynamic allows:
- Conformity assessment of the overhead contact line
- Reduction of the measuring expenditure and the corresponding costs in the approval of rolling stock with many combination possibilities of the pantographs
- Increase the catenary quality
- Even wear of the pantograph

Typical scenarios
- Development of overhead contact lines for highest speeds up to 350 km/h
- Investigation of special configurations (overhead contact lines in tunnels, overhead contact lines above points with crossing rod, third rail, overhead contact lines without steady army)
- Simulations in the framework of TSI certifications for different catenary systems and trains with different combinations of trainsets

Program structure

The data required for the description of the catenary, the geometry defined by forces and fixed points as well as the material properties are entered in Sicat Dynamic. The coordinates of the nodes between the fixed points are checked internally and corrected by the program if necessary, until the catenary model is exactly in static equilibrium.

Based on this static equilibrium, the use of pantographs can be simulated under the following conditions:
- Running speed
- Number of and distance between pantographs
- Forces on the pantographs
- Pantograph type



Program structure Sicat Dynamic

Input block

Using accurate input data, both the catenary and the pantograph are precisely modeled.

The following data are being entered:

Input data

Pantograph parameters (in compliance with the 3-mass-model)
- Masses
- Spring stiffness
- Damping
- Friction

Catenary parameters
- Contact wire: number, material, cross-section, tensile force t
- Catenary wire: number, material, cross-section, tensile force
- Stitch wire: number, material, length, cross-section, tensile force
- Droppers: material, cross-section
- Clamps: mass
- Steady arms: length, mass
- Geometry:
  - Span length
  - Dropper spacing
  - System height
  - Contact wire height
  - Presag (amount and range of droppers)
  - Stagger for contact wire and catenary wire
  - Tension length
  - In case of two tension lengths: wire height and horizontal distance in overlaps
- For all materials: density, modulus of elasticity, Poisson ratio, temperature coefficient (fixed termination only)

Simulation parameters
- Running speed
- Number and distances of pantographs
- Static, aerodynamic forces and aerodynamic correction forces
- Pantograph type
- Limits of the analysis section
- Temperature of ropes and wires (fixed termination only)

Calculation block

In the standard model no tolerances in track and overhead contact line, no thermal influences and only straight tracks are considered. For simulation with curved tracks, rail coordinates and cant are needed in addition. Data needed for modeling overlaps are the vertical and horizontal gradient of the contact wires along with the catenary wire heights at the supports as follows:

Overlap

- Contact wire heights at the traversed supports (usually nominal contact wire height)
- Contact wire heights at the uplifted supports
- Gradient function of contact wire height (square, cubic, etc.)
- Contact wire height at the tensioning device
- Lateral position of contact wires at twin supports
- Longitudinal distance of twin cantilevers at mid supports
- System heights in overlaps
- Indication of supports without stitch wire or with modified design of stitch wire

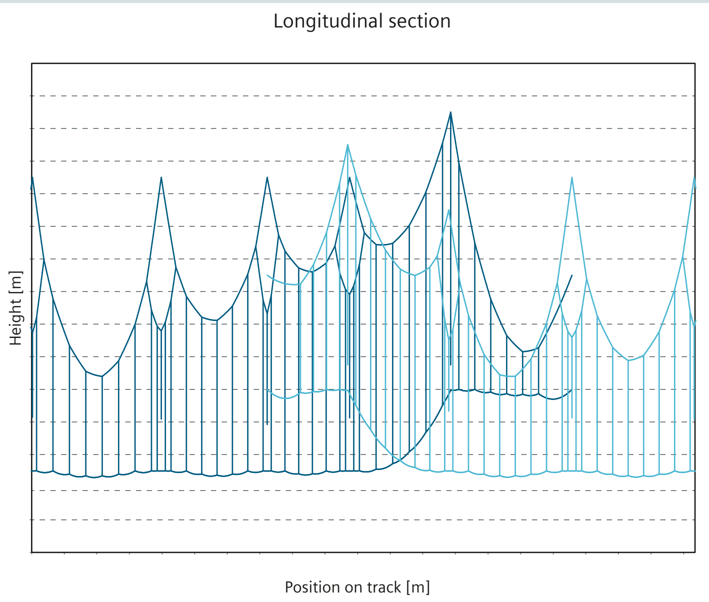
Output block

Contact wire uplift and contact force, the relevant values for the current collection quality are determined and can be graphically represented. This allows the indication of the critical („worst-case“) combinations for which test runs should be performed.

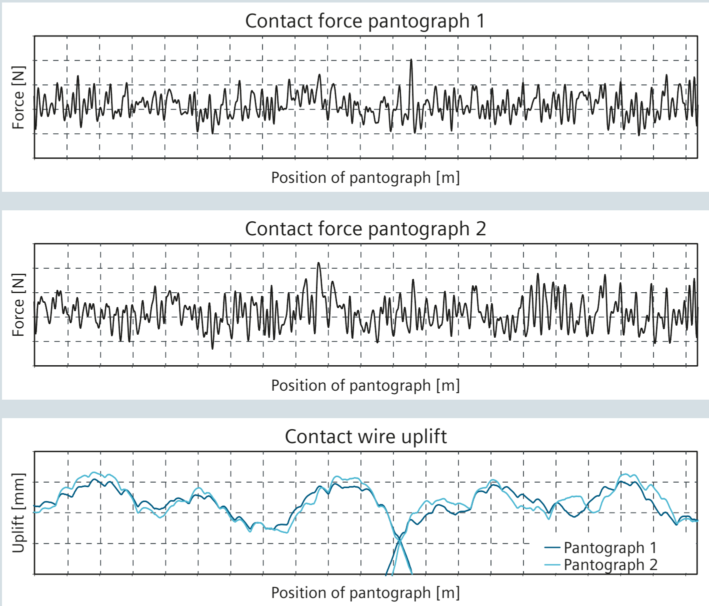
Outputs

Contact force Fc versus track = Fc (x):
- Average value Fm
- Standard deviation σ and σ / Fm (evaluation parameter acc. to EN 50367)
- Statistic maximum and minimum of contact force Fm ± 3σ
- Current maximum and minimum of contact force

Uplift y of contact wire above distance = y (x):
- Maximum uplift at support



Longitudinal section at overlap



Contact force and contact wire uplift over distance

Application example: Approval of rolling stock

If more than one pantograph is in use, the trailing pantographs are affected by a moving contact line, which in general leads to a degradation of the contact quality.

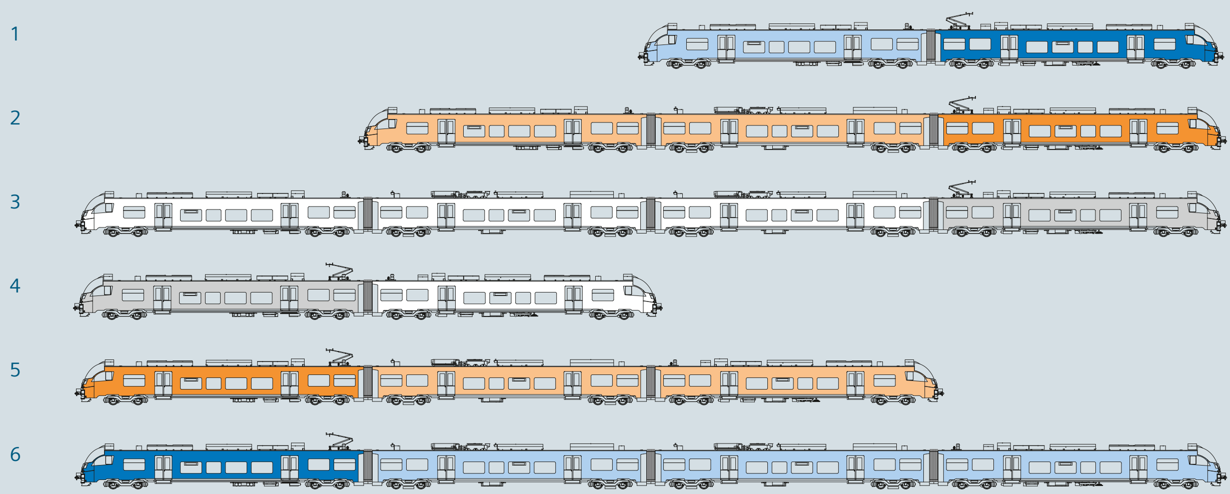
Particularly for the approval of multiple unit trains this results in a high cost for the certification of conformity, as in principle all possible train formations and corresponding different pantograph arrangements must be checked.

Combinatorics of trainsets
The picture shows how many calculation cases already arise using only one active pantograph when three different train lengths are used. The active trains are marked by darker colors and an uplifted pantograph, trains move in right direction.

The top three lines show the same calculation case, as it is assumed that subsequent cars have no influence on the flow and thus on the aerodynamic forces on the pantographs. In the three bottom lines however different forces are to be expected, as the flow changes due to the additional trains. Thus, four cases arise which need to be distinguished.

By dynamic simulation with Sicat Dynamic the critical combinations can be identified. By consulting the notified body, a combination of real measurements and simulations can be agreed upon to reduce the regulatory burden.

Number of pantographs	One trainset	Two trainsets	2-parts, 3-parts and 4-parts trainset
1	2	3	4
2	4	11	20
3	8	41	104
4	16	153	544
5	32	571	2.881



Calculation cases in single trancion for 2-parts, 3-parts and 4-parts trainsets; travel direction to the right;
Case 1 to 3: spit-speed transition, case 4 to 6: knees transition

Sicat Dynamic / Product information
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