

The Siemens logo is displayed in a bold, teal, sans-serif font. It is positioned in the upper left corner of the page, set against a white rectangular background that partially overlaps the blurred image of a high-speed train and the railway infrastructure.

SIEMENS

Ingenuity for life

The background of the entire page is a blurred photograph of a modern railway station. A high-speed train is moving from left to right, creating a sense of motion. The station's roof is a complex structure of dark, parallel beams. Overhead power lines and support poles are visible, extending into the distance. The overall color palette is dominated by blues, greys, and the white of the train.

System design with Sitras Sidytrac and Sitras EMF

Simulation of AC and DC traction power supply

[siemens.com/rail-electrification](https://www.siemens.com/rail-electrification)

At the system design of railway electrification systems we combine the calculations of our simulation tool Sitras® Sidytrac with our extensive system know-how.

With the help of the software the workflows will be standardized and automated, so sources of errors are reduced and the efficiency are increased.

Features

- Detailed design of new AC or DC traction systems with electrical dimensioning of substations and contact line systems:
 - Economical design of the entire system
 - Calculation of power reserves for further extensions
- Multi-train simulation with integrated electrical load flow calculation
- Short circuit calculation along defined line sections
- Induced Voltage calculation in parallel conductors
- Electric and magnetic field calculation along the line
- Highly automated comprehensive and customer-specific adaptable browser-enabled format of results in standardized tables and graphics for easy documentation
- Automatically processed predefined standard reports and special evaluations for e.g. induced voltages, magnetic fields, protection impedances, stray current, equivalent thermal loads, etc.
- Comprehensive possibility for variant calculations and results comparisons at a glance, e.g. variants of network switching states and feeding configurations, train schedules, fault conditions.

Areas of application

With the help of Sitras Sidytrac the system design and calculation of the complete traction power supply system is carried out..

Overall system design

- Simulated train operation and network calculation for AC and DC railways
- Optimization of feeding concepts
- Definition of substation locations
- Energy demand calculations for railway lines
- Calculation and assessment of contingency operation
- Current load of contact lines, cables, busbars, switch-gears and transformers
- Calculation of line impedances and potentials along the line
- Assessment of controlled substations (inverter, double converter), energy storage units
- Calculation of current distribution of contact lines
- Dimensioning of rail active balancer Sitras RAB plus and mobile rail VAR compensator Sitras RVC plus

Safety of persons and protection of installations

- Calculation of rail potentials / touch voltages
- Assessment of stray currents for DC railways

Protection design

- Short circuit calculations DC / AC railways
- Maximum operational currents of feeding sections
- Design parameters for relay coordination
- Contact line protection impedances
- Protection simulation for overcurrent and distance protection

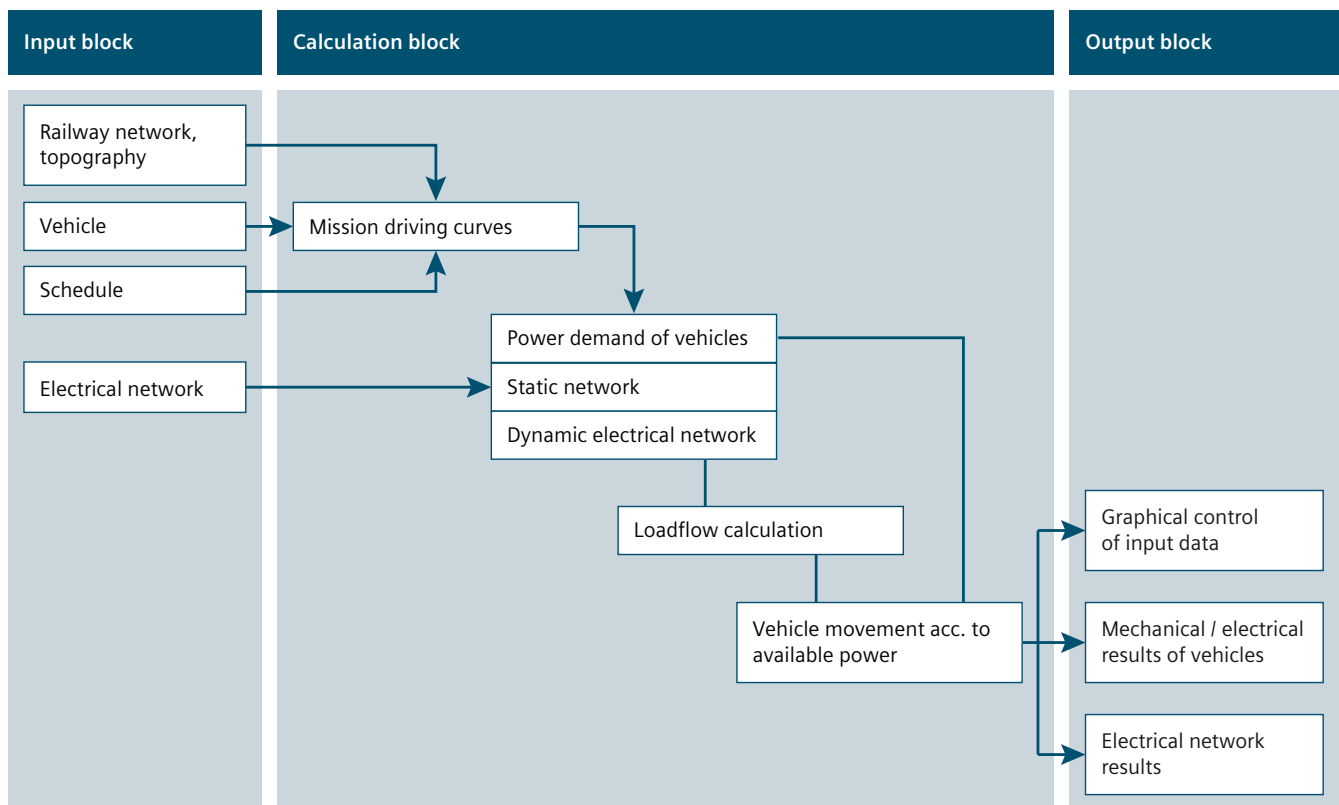
Network reaction / power quality

- 3-phase unbalance because of single-phase railway loads
- 3-phase voltage fluctuation study
- Resonance behavior of railway lines

Interference, magnetic fields, electromagnetic compatibility

- Studies and calculations of electric and magnetic fields of railway lines and/or traction substations
- Calculation of psophometric interference in telecommunication cables, i. e. frequency analysis of the electromagnetic interference
- Mutual interference between DC and AC railways
- Induced voltages in parallel conductors, e. g. cable screens and signal lines

Program structure



Licenses

Sitras Sidytrac is available in three basic license editions, with a set of basic functions, which covers many use cases.

The modular structure of the license editions offers further package options for either DC or AC electric traction systems or both and allows optimal customizable solutions for individual needs.

Data input and modeling environment

The graphical user interface Sidytrac Studio features data input, modeling, configuration and control of the complete simulation process including configuration of output and results processing.

Input Data

Railway network, topography

- Railway network with sections, tracks, stations
- Topography with chainage, gradients, curve radii, location and type of tunnels
- Speed profiles, current limitations
- Blocksignals, time controlled Signals

Vehicle data

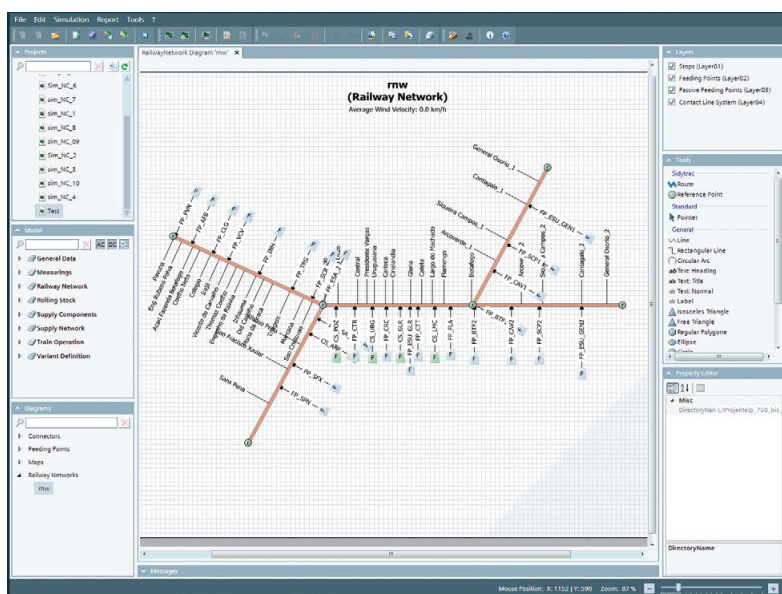
- Mass, Maximum speed, acceleration, deceleration
- Efficiency, power factor, traction current limitations
- Traction and braking efforts, rolling resistances
- Auxiliaries, power consumption, onboard energy storages

Schedule

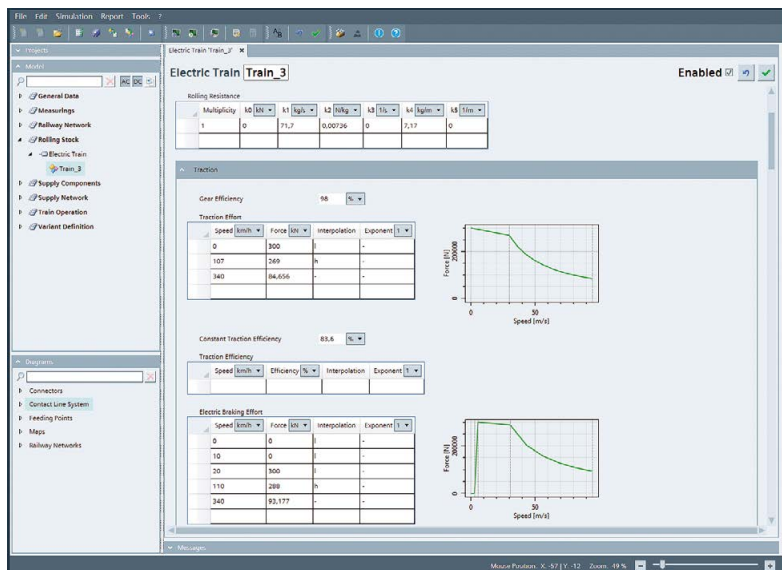
- Synchronized schedules, individual schedules
- Quasi-stochastic schedules

Electrical network

- Network topology, feeding points and fault levels
- Transformers, rectifiers, inverters, energy storage units, reactive power compensation
- Switchgears, feeder conductors, resistors, reactors, capacitors, stationary consumers
- Contact line system (lumped impedance and multiconductor model)



Input railway network



Input electric train

Calculation

Multitrain simulation and load flow calculation

The calculation runs in the time step method, where two processes are carried out for each step.

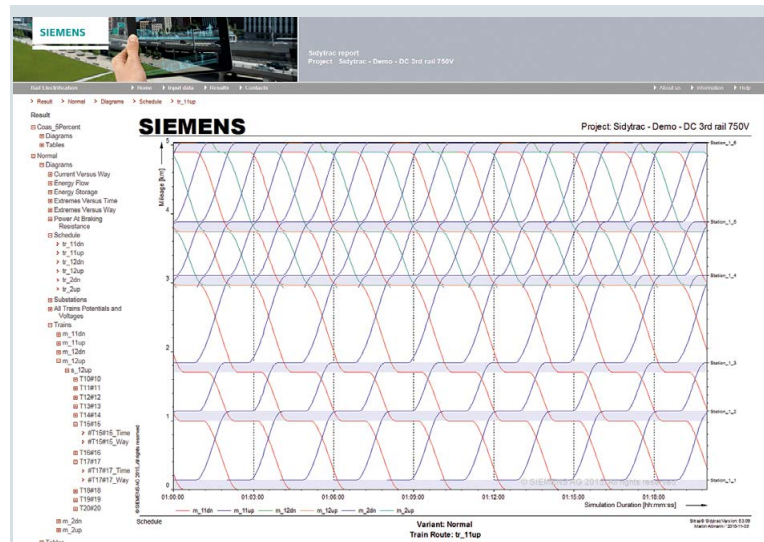
First, the dynamic drive cycle calculation solves the kinematic equations, computes the operation of the trains in the network and determines the required propulsion power for the next time step. The train model accepts various train and motor data as well as the definition of different driving modes, such as all out running or coasting, so that a broad variety of electric traction systems can be modeled. Depending on various train run parameters, e.g. driving curves and state, topography, line side limitations, etc. the time step will automatically be reduced to increase the accuracy.

Next, the resulting electrical train loads are integrated into the static electrical network forming a common dynamic electrical network, with the trains representing time-dependent and movable power sinks and sources. For this common electrical network the electrical load flow is solved, i.e. the complex currents, voltages and available power for all nodes and branches of the network are determined at fundamental frequency.

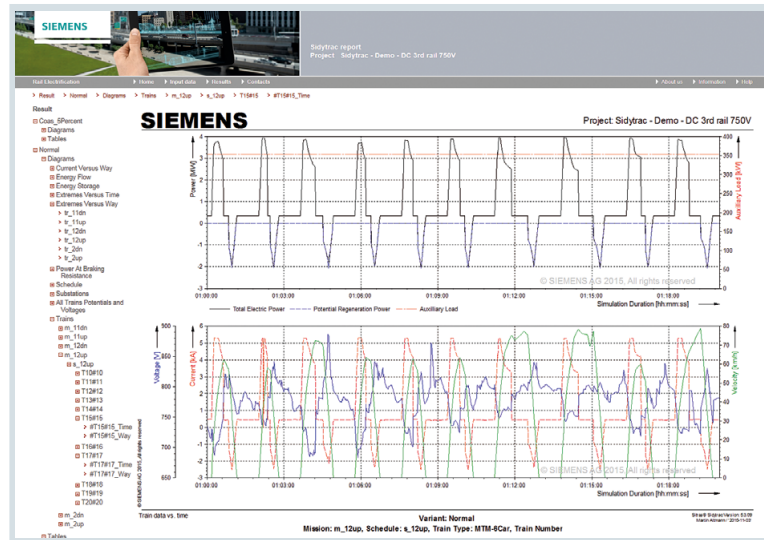
The contact line system can either be modeled in sections with lumped impedance or with a multiconductor model considering full magnetic and capacitive coupling. Additionally Sidytrac features a customisable automatic pre-process for multiconductor to lumped model conversion, which allows a very fast, simplified calculation without the need for pre-calculation of the individual lumped impedances.

The load flow calculation is performed using the node potential method. For optimizing the calculation speed of large networks with many nodes advanced numerical solving methods are available, automatically adapting depending on the convergence of the iteration.

Thanks to this iterative method the interdependencies between the traction power supply performance and the requirements of electric traction are calculated most realistically, such as the effect on the running time of the individual trains, the actual regeneration power as well on the network and component loads.



Multitrain simulation: Schedule



Multitrain simulation: train voltages and currents

Output and data processing

The simulation results and input data are stored and automatically processed in a database, which allows comfortable and advanced individual post processing.

Furthermore Sidytrac Studio offers a predefined browser-enabled report format. This Sidytrac Report comprises of manifold diagrams and tables for evaluation of the electrical key data of the individual simulation variants, as well of variant comparisons for currents, voltages, power and energy. System analysis and energy optimization are ideally supported.

Output Data

Graphical control of input data

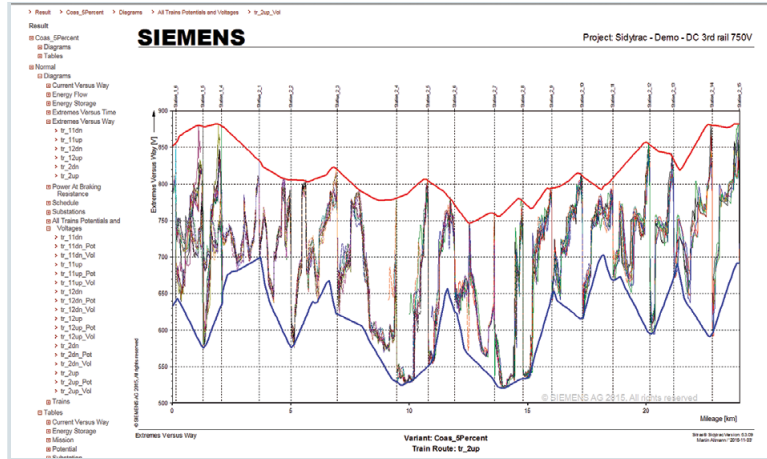
- Railway network, topography, electrical network topology
- Vehicle characteristics and limitations
- Graphical schedule, calculated

Vehicle results

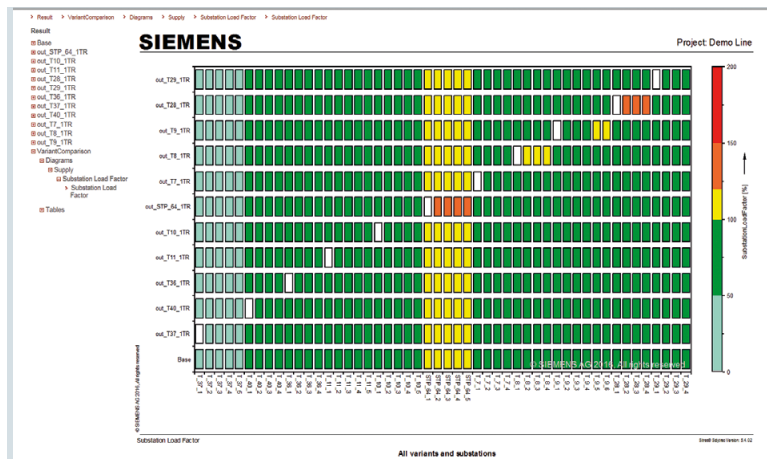
- Currents, Voltages
- Total power, recuperated power
- Traction power and energy, auxiliary demand, power at wheel, losses
- Power factor, efficiencies
- Position, speed, acceleration
- Traction effort, braking effort

Electrical network results

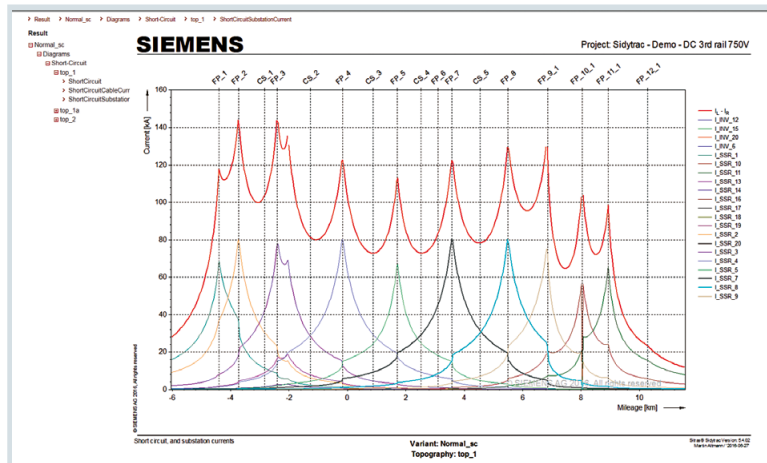
- Conductor currents in network branches, supply voltages
- Extreme values of train voltage, rail potential
- Total power, active power, losses
- Power factor, unbalance, flicker
- Energy balance
- Conductor currents along the line
- Short-circuit currents
- Stray currents
- Induced voltages
- Impedance for protection relay settings
- Magnetic fields



Output train voltages



Output Variant comparison of substation power



Output Short-circuit currents along the line

Areas of application

Sitras EMF complements the program family of Sitras Sidytrac and allows the calculation of manifold geometrical arrangements of conductors with regard to:

- Electric field strength
- Magnetic field strength
- Magnetic induction
- Electric noise level
- Surface electric field gradient.

Overview and operating principle

Sitras EMF allows calculating electric and magnetic fields as well acoustic noise, which can occur in transmission lines or contact lines of electric traction systems. The user defines general input data, such as geometry and material properties of the conductors.

The calculation of the field strength noise level is performed in a Cartesian coordinate system, which is defined by the user together with a grid of measuring points.

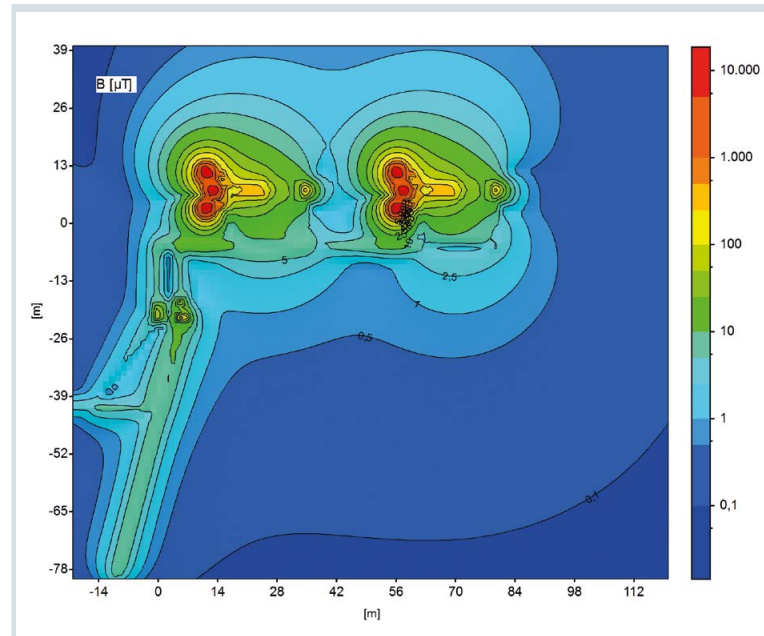
For the magnetic field calculation the conductor currents have to be available. The geometrical conductor arrangement can be modelled by a polygon course, i.e. EMF is able to calculate any 3-dimensional configuration. The magnetic fields are calculated according the laws of Biot-Savart and the electric fields by means of the complex image method.

The results can be displayed along a straight measuring line or two dimensional measuring planes. For measuring planes the numerical values are visualized in isolines of equal magnitude.

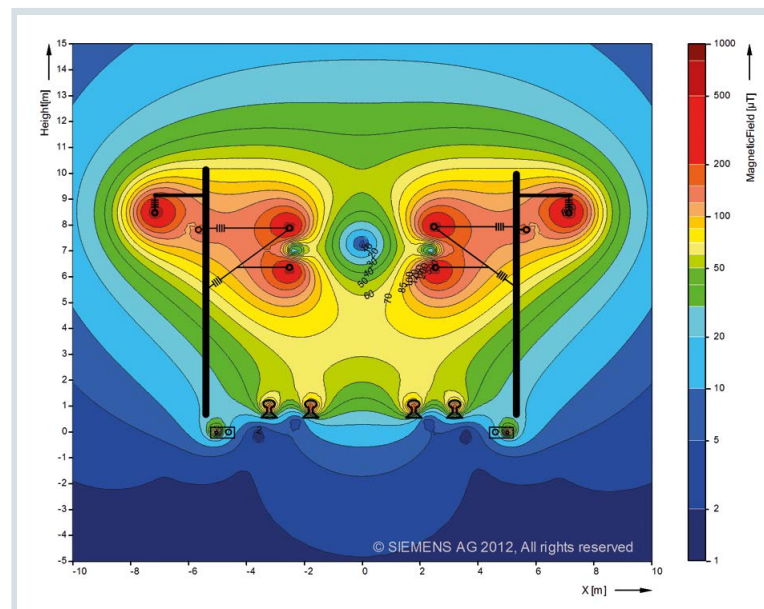
All input data and the measuring geometry are stored in a file.

The calculated border field strength, electric charge, field strength and noise level are stored in separate ASCII files, which are optimized for post processing in the measurement data base FlexPro.

The graphical illustration of the fields and noise level, as well as the conductor geometry is done with the commercial data analysis and presentation software FlexPro. The graphics can be post processed in FlexPro and exported in various graphic and report formats.



Magnetic field of an AC electric traction power installation



Magnetic field along a 2 x 25 kV AC line

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Sitras Sidytrac / Sitras EMF / Product information
No. A6Z08110389260 / Version 2.0.1

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