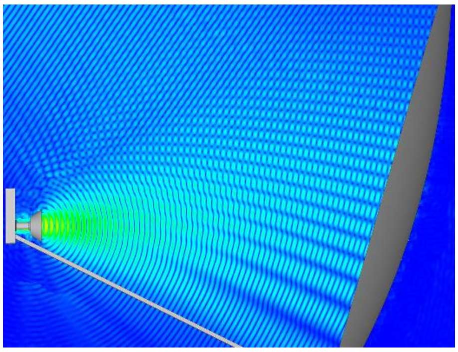
CST STUDIO SUITE



CST Studio Suite® gives customers access to multiple electromagnetic (EM) simulation solvers which use methods such as the finite element method (FEM) the finite integration technique (FIT), and the transmission line matrix method (TLM). These represent the most powerful general purpose solvers for high frequency simulation tasks.

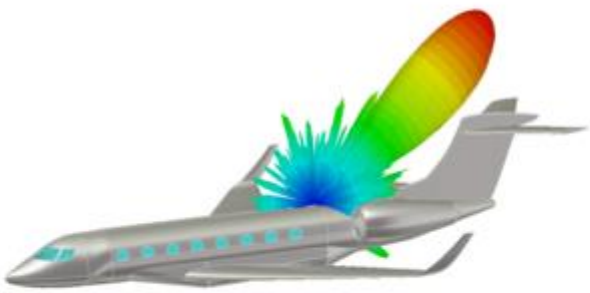
Additional solvers for specialist high frequency applications such as electrically large or highly resonant structures complement the general purpose solvers.

CST Studio Suite includes FEM solvers dedicated to static and low frequency applications such as electromechanical devices, transformers or sensors. Alongside these are simulation methods available for charged particle dynamics, electronics, and multiphysics problems.

The seamless integration of the solvers into one user interface in CST Studio Suite enables the easy selection of the most appropriate simulation method for a given problem class, delivering improved simulation performance and unprecedented simulation reliability through cross-verification.

High Frequency

Asymptotic

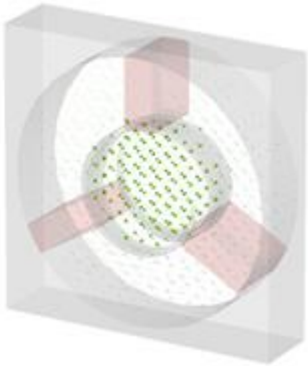


The Asymptotic Solver is a ray tracing solver which is efficient for extremely large structures where a full-wave solver is unnecessary. The Asymptotic Solver is based on the Shooting Bouncing Ray (SBR) method, an extension to physical optics, and is capable of tackling simulations with an electric size of many thousands of wavelengths.

Applications:

- Electrically very large structures
- Installed performance of antennas
- Scattering analysis

Eigenmode

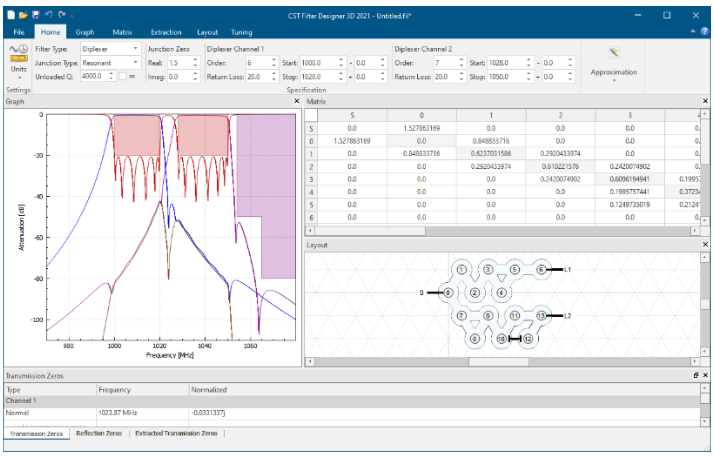


The Eigenmode Solver is a 3D solver for simulating resonant structures, incorporating the Advanced Krylov Subspace method (AKS), and the Jacobi-Davidson method (JDM). Common applications of the Eigenmode Solver are highly-resonant filter structures, high-Q particle accelerator cavities, and slow wave structures such as travelling wave tubes. The Eigenmode Solver supports sensitivity analysis, allowing the detuning effect of structural deformation to be calculated directly.

Applications:

- Filters
- Cavities
- Metamaterials and periodic structures

Filter Designer 3D



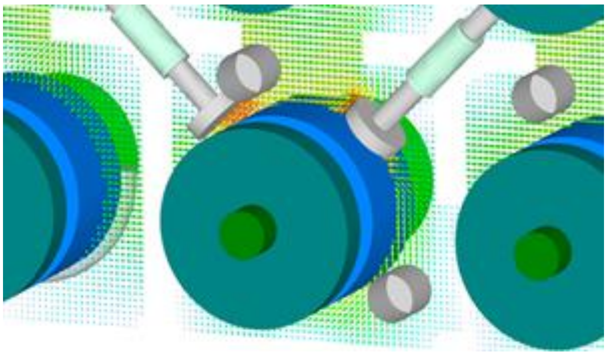
A synthesis tool for designing bandpass and diplexer filters, where a range of coupling matrix topologies are produced for the application in arbitrary coupled-resonator based technology. It also offers a choice in building blocks to realize the 3D filter by making use of the Assembly Modelling. From the Component Library the user can choose between combline/interdigital coaxial cavities and rectangular waveguides, or simply define customized building blocks of any type of single-mode technology (e.g. SIW or dielectric pucks).

Additional functionality includes the coupling matrix extraction that can directly be used as a goal for optimization of a simulation model, or for assistance in tuning complex hardware via real-time measurements using a network analyzer.

Applications:

- Cross-coupled filters for different electromagnetic technologies (e.g. cavities, microstrip, dielectrics)
- Assistive tuning for filter hardware (with vector network analyzer link)

Frequency Domain

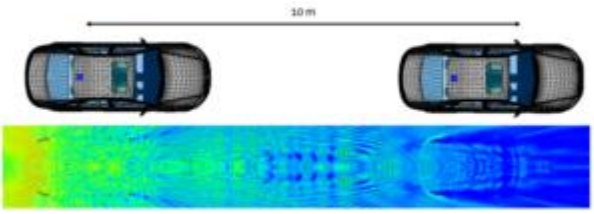


The Frequency Domain Solver is a powerful multi-purpose 3D full-wave solver, based on the finite element method (FEM), that offers excellent simulation performance for many types of component. Because the Frequency Domain Solver can calculate all ports at the same time, it is also a very efficient way to simulate multi-port systems such as connectors and arrays. The Frequency Domain Solver includes a model-order reduction (MOR) feature which can speed up the simulation of resonant structures such as filters.

Applications:

- General high-frequency applications using small-to-medium sized models
- Resonant structures
- Multi-port systems
- 3D electronics

Integral Equation



The Integral Equation Solver is a 3D full-wave solver, based on the method of moments (MOM) technique with multilevel fast multipole method (MLFMM). The Integral Equation Solver uses a surface integral technique, which makes it much more efficient than full volume methods when simulating large models with lots of empty space. The Integral Equation Solver includes a characteristic mode analysis (CMA) feature which calculates the modes supported by a structure.

Applications:

- High-frequency applications using electrically large models
- Installed performance
- Characteristic mode analysis

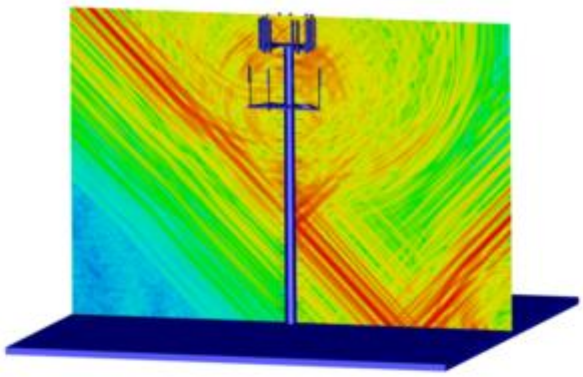
Multilayer

The Multilayer Solver is a 3D full-wave solver, based on the method of moments (MOM) technique. The Multilayer Solver uses a surface integral technique and is optimized for simulating planar microwave structures. The Multilayer Solver includes a characteristic mode analysis (CMA) feature which calculates the modes supported by a structure.

Applications:

- MMIC
- Feeding networks
- Planar antennas

Time Domain



The Time Domain Solver is a powerful and versatile multi-purpose 3D full-wave solver, with both finite integration technique (FIT) and transmission line matrix (TLM) implementations included in a single package. The Time Domain Solver can perform broadband simulations in a single run. Support for hardware acceleration and MPI cluster computing also makes the solver suitable for extremely large, complex, and detail-rich simulations.

Applications:

- General high-frequency applications using medium-to-large models.
- Transient effects
- 3D electronics

Hybrid Solver Task

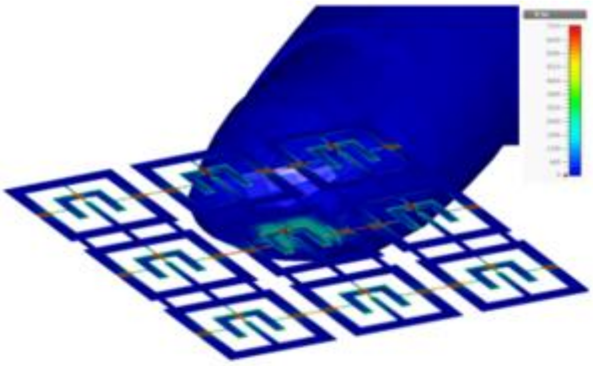
The Hybrid Solver Task allows the Time Domain, Frequency Domain, Integral Equation and Asymptotic Solvers to be linked for hybrid simulation. For simulation projects that involve very wide frequency bands or electrically large structures with very fine details, calculations can be made much more efficient by using different solvers on different parts. Simulated fields are transferred between solvers through field sources, with a bidirectional link between the solvers for more accurate simulation.

Applications:

- Small antennas on very large structures
- EMC simulation
- Human body simulation in complex environments

Low Frequency

Electrostatic



The Electrostatic Solver is a 3D solver for simulating static electric fields. This solver is especially suitable for applications such as sensors where electric charge or capacitance is important. The speed of the solver also means that it is very useful for optimizing applications such as electrodes and insulators.

Applications:

- Sensors and touchscreens
- Power equipment
- Charged particle devices and X-ray tubes

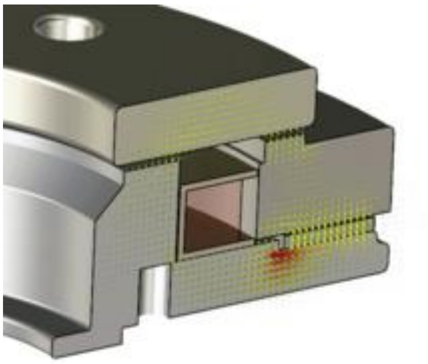
Stationary Current

The Stationary Current Field Solver is a 3D solver for simulating the flow of DC currents through a device, especially with lossy components. This solver can be used to characterize the electrical properties of a component that is DC or in which eddy currents and transient effects are irrelevant.

Applications:

- High-power equipment
- Electrical machines
- PCB power distribution network

Magnetostatic



The Magnetostatic Solver is a 3D solver for simulating static magnetic fields. This solver is most useful for simulating magnets, sensors, and for simulating electrical machines such as motors and generators in cases where transient effects and eddy currents are not critical.

Applications:

- Sensors
- Electrical machines
- Particle beam focusing magnets

Low Frequency – Frequency Domain

The Low-Frequency Frequency Domain (LF-FD) Solver is a 3D solver for simulating the time-harmonic behaviour in low frequency systems, and includes magneto-quasistatic (MQS), electro-quasistatic (EQS) and full wave implementations. This solver is most useful for simulations that involve frequency-domain effects and where the sources are coils.

Applications:

- Sensors and non-destructive testing (NDT)
- RFID and wireless power transfer
- Power engineering – bus bar systems

Low Frequency – Time Domain

The Low-Frequency Time Domain (LF-FD) Solver is a 3D solver for simulating the transient behaviour in low frequency systems, and includes both magneto-quasistatic (MQS) and electro-quasistatic (EQS) implementations. The MQS solver is suitable for problems involving eddy currents, non-linear effects, and transient effects such as motion or inrush. The EQS solver is suitable for resistive-capacitive problems and HV-DC applications.

Applications:

- Electrical machines and transformers
- Electromechanical - motors, generators
- Power engineering – insulation, bus bar systems, switchgear

Multiphysics

Thermal Steady State Solver

The Thermal Steady State Solver can predict temperature distribution of a steady-state system. Heat sources can include losses generated by electric and magnetic fields, currents, particle collisions, human bio-heat, as well as other user-defined sources. Seamlessly linked to our electromagnetic solvers, the Thermal Steady State Solver enables temperature prediction of devices and resulting impact on their electromagnetic performance.

Applications:

- High-power electronics components and devices, such as print circuit boards (PCBs), filters, antennas etc.
- Medical devices and human bio-heating

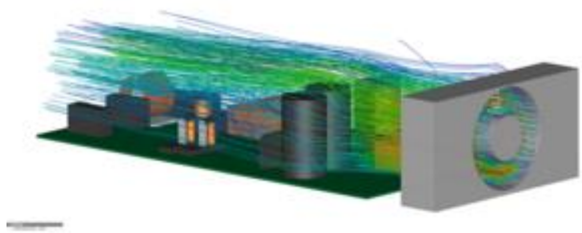
Thermal Transient Solver

The Thermal Transient Solver can predict time-varying temperature response of a system. Heat sources can include losses generated by electric and magnetic fields, currents, particle collisions, human bio-heat, as well as other user-defined sources. Seamlessly linked to our electromagnetic solvers, the Thermal Transient Solver enables transient temperature prediction of devices and resulting impact on their electromagnetic performance.

Applications:

- High-power electronics components and devices, such as PCBs, filters, antennas etc.
- Medical devices and human bio-heating

Conjugate Heat Transfer (CHT) Solver



The Conjugate Heat Transfer (CHT) Solver uses CFD technique to predict fluid flow and temperature distribution in a system. The CHT solver includes the thermal effects from all heat transfer modes: conduction, convection, and radiation, and can include heat sources from electromagnetic losses just as the Steady State and Transient Thermal solvers do. Devices such as fans, perforated screens, thermal interface materials can be directly modeled. Compact thermal models (CTM), such as two-resistor CTM, can also be considered.

Applications:

- Electronics cooling: natural and forced convection of high-power electronics components and devices, such as PCBs, filters, antennas, chassis etc. with installed cooling devices such as fans, heatsinks etc.

Mechanical Solver

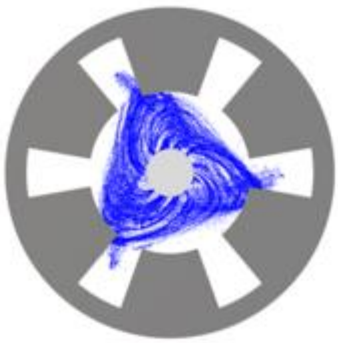
The Mechanical Solver can predict structures' mechanical stress and deformation caused by electromagnetic forces and thermal expansion. It is designed to be used in conjunction with the EM and thermal solvers to assess the possible performance impact of the force and heating to the device.

Applications:

- Filter detuning
- PCB deformation
- Lorentz forces on particle accelerators

Particles

Particle-in-Cell (PIC) Solver

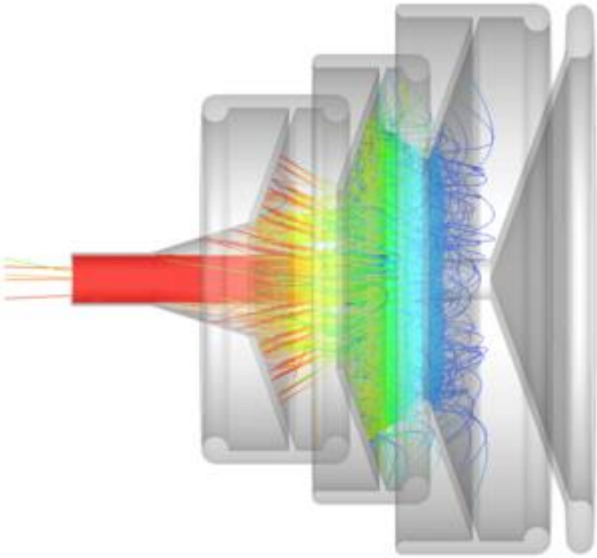


The Particle-in-Cell (PIC) Solver is a versatile, self-consistent simulation method for particle tracking that calculates both particle trajectory and electromagnetic fields in the time-domain, taking into account the space charge effects and mutual coupling between the two. This allows it to be used to simulate a huge variety of devices where the interaction between particles and high-frequency fields are important, as well as high-power devices where electron multipacting is a risk.

Applications:

- Accelerator components
- Slow-wave devices
- Multipaction

Particle Tracking Solver

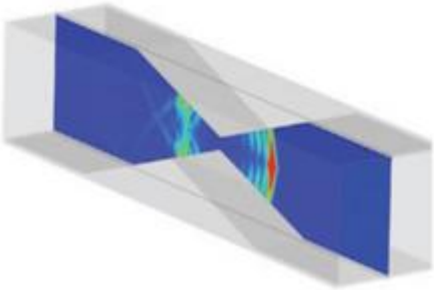


The Particle Tracking Solver is a 3D solver for simulating particle trajectories through electromagnetic fields. The space charge effect on the electric field can be taken into account by the Gun Iteration option. Several emission models including fixed, space charge limited, thermionic and field emission are available, and secondary electron emissions can be simulated.

Applications:

- Particle sources
- Focusing and beam steering magnets
- Accelerator components

Wakefield Solver



The Wakefield Solver calculates the fields around a particle beam, represented by a line current, and the wakefields produced through interactions with discontinuities in the surrounding structure.

Applications:

- Cavities
- Collimators
- Beam position monitors

EMC and EDA

PCB Solvers

The PCBs and Packages Module of CST Studio Suite is a tool for signal integrity (SI), power integrity (PI), and electromagnetic compatibility (EMC) analysis on printed circuit boards (PCB). It integrates easily into the EDA design flow by providing powerful import filters for popular layout tools from Cadence, Zuken, and Altium. Effects like resonances, reflections, crosstalk, power/ground bounce and simultaneous switching noise (SSN) can be simulated at any stage of product development, from pre-layout to post-layout phase.

CST Studio Suite includes three different solver types – a 2D Transmission Line method, a 3D Partial Element Equivalent Circuit (PEEC) method and a 3D Finite-Element Frequency-Domain (FEFD) method – and pre-defined workflows for IR drop, PI and SI analysis

Applications:

- High-speed PCBs
- Packages
- Power electronics

Rule Check

Rule Check is an EMC, SI and PI design rule checking (DRC) tool that reads popular board files from Cadence, Mentor Graphics, and Zuken as well as ODB++ (e.g. Altium) files and checks the PCB design against a suite of EMC or SI rules. The kernel used by Rule Check is the well-known software tool EMSAT.

The user can designate various nets and components that are critical for EMC, such as I/O nets, power/ground nets, and decoupling capacitors. Rule Check relieves the tedium and removes the human error by examining each critical net in turn to check that it does not violate any of the selected EMC or SI design rules. After the rule checking is completed, the EMC rules' violations can be viewed graphically or as an HTML document.

Applications:

- Electromagnetic compatibility (EMC) PCB design rule checking
- Signal integrity and power integrity (SI/PI) PCB design rule checking

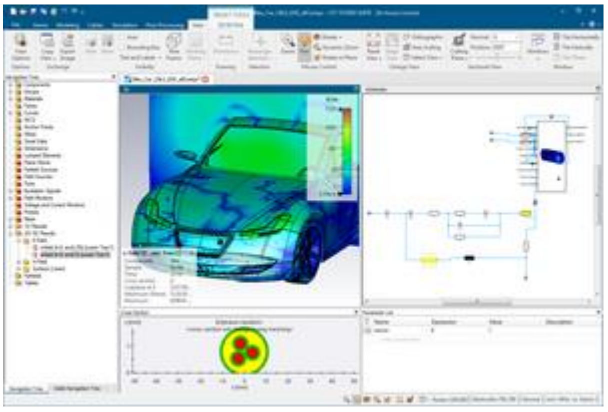
Cable Harness

The Cable Harness Solver is dedicated to the three-dimensional analysis of signal integrity (SI), conducted emission (CE), radiated emission (RE), and electromagnetic susceptibility (EMS) of complex cable structures in electrically large systems. It incorporates a fast and accurate transmission line modeling technique for cable harness configurations in 3D metallic or dielectric environment. Hybrid simulation with the Cable Harness Solver and other high-frequency solvers allows structures containing complex cable harnesses to be simulated in 3D efficiently.

Applications:

- General SI and EMC simulation of cables
- Cable harness layout in vehicles and aircraft
- Hybrid cables in consumer electronics

ELECTROMAGNETIC SYSTEMS MODELING



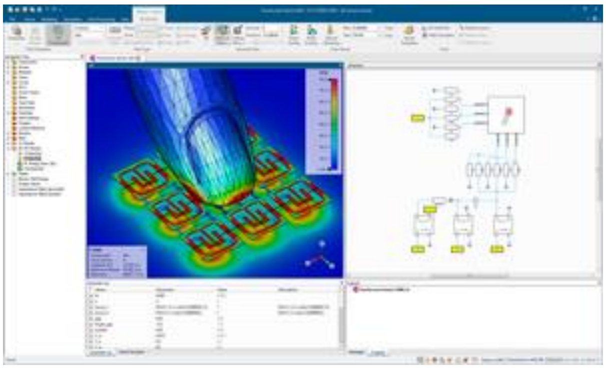
With System Assembly and Modeling (SAM), CST Studio Suite® provides an environment that simplifies the management of simulation projects, enabling the intuitive construction of electromagnetic (EM) systems and straightforward management of complex simulation flows using schematic modeling.

The SAM framework can be used for analyzing and optimizing an entire device that consists of multiple individual components. These are described by relevant physical quantities such as currents, fields or S-parameters. SAM enables the use of the most efficient solver technology for each component.

SAM helps users to compare the results of different solvers or model configurations within one simulation project and perform post-processing automatically. SAM facilities the set-up of a linked sequence of solver runs for hybrid and multiphysics simulations. For example using the results of EM simulation to calculate thermal effects, then structural deformation, and then another EM simulation to analyze detuning.

This combination of different levels of simulation helps to reduce the computational effort required to analyze a complex model accurately.

ELECTROMAGNETIC DESIGN ENVIRONMENT

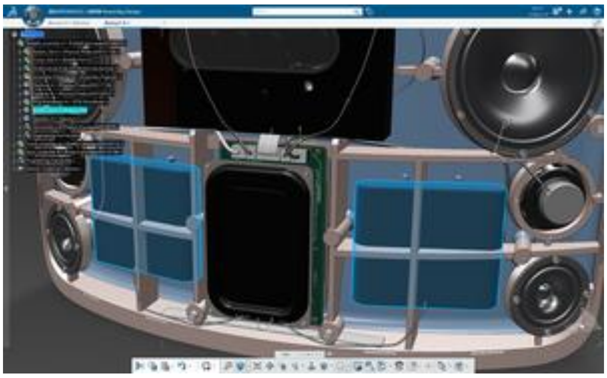


The CST Studio Suite® design environment is an intuitive user interface used by all the modules. It comprises a 3D interactive modeling tool, a schematic layout tool, a pre-processor for the electromagnetic solvers and post-processing tools tailored to industry needs.

The ribbon-based interface uses tabs to display all the tools and options needed to set up, carry out and analyze a simulation, grouped according to their position in the workflow. Contextual tabs mean that the most relevant options for the task are always just a click away. In addition, the Project Wizard and the QuickStart Guide provide guidance to new users and offer access to a wide range of features.

The 3D interactive modeling tool at the heart of the interface uses the ACIS 3D CAD kernel. This powerful tool enables complex models to be constructed within CST Studio Suite and edited parametrically with a simple WYSIWYG approach.

WORKFLOW INTEGRATION

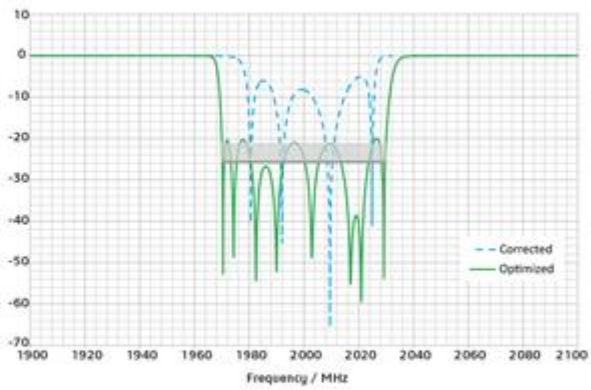


The excellent workflow integration available within CST Studio Suite® provides reliable data exchange options which help to reduce the design engineer's workload.

CST Studio Suite is renowned for its superb CAD and EDA data import capabilities. The sophisticated healing mechanisms, which restore the integrity of flawed or non-compliant data, are particularly important as even one corrupted element can prevent the use of the whole part.

Fully parametrized models can be imported and design changes are instantly reflected in the simulation model due to the bidirectional link between CAD and simulation. This means that the results of optimizations and parametric design studies can be imported back directly into the master model. This improves workflow integration and reduces the time and effort needed to optimize a design.

AUTOMATIC OPTIMIZATION



CST Studio Suite® offers automatic optimization routines for electromagnetic systems and devices. CST Studio Suite models can be parameterized with respect to their geometrical dimensions or material properties. This enables users to study the behavior of a device as its properties change.

Users can find the optimum design parameters to achieve a given effect or fulfill a certain goal. They can also adapt material properties to fit measured data.

CST Studio Suite contains several automatic optimization algorithms, both local and global. Local optimizers provide fast convergence but risk converging to a local minimum rather than the overall best solution. On the other hand, global optimizers search the entire problem space but typically require more calculations.

High-performance computing techniques can be used to speed up simulation and optimization for very complex systems, or problems with large numbers of variables. The performance of global optimizers in particular can be greatly improved with the use of distributed computing.

Covariance Matrix Adaptation Evolutionary Strategy

The Covariance Matrix Adaptation Evolutionary Strategy (CMA-ES) is the most sophisticated of the global optimizers, and has relatively fast convergence for a global optimizer. With CMA-ES, the optimizer can “remember” previous iterations, and this history can be exploited to improve the performance of the algorithm while avoiding local optimums.

Suitable for: General optimization, especially for complex problem domains

Trust Region Framework

A powerful local optimizer, which builds a linear model on primary data in a "trust" region around the starting point. The modeled solution will be used as new starting point until it converges to an accurate model of the data. The Trust Region Framework can take advantage of S-parameter sensitivity information to reduce the number of simulations needed and speed up the optimization process. It is the most robust of the optimization algorithms.

Suitable for: General optimization, especially on models with sensitivity information

Genetic Algorithm

Using an evolutionary approach to optimization, the Genetic Algorithm generates points in the parameter space and then refines them through multiple generations, with random parameter mutation. By selecting the “fittest” sets of parameters at each generation, the algorithm converges to a global optimum.

Suitable for: Complex problem domains and models with many parameters

Particle Swarm Optimization

Another global optimizer, this algorithm treats points in parameter space as moving particles. At each iteration, the position of the particles changes according to, not only to the best known position of each particle, but also the best position of the entire swarm as well. Particle Swarm Optimization works well for models with many parameters.

Suitable for: Models with many parameters

Nelder Mead Simplex Algorithm

This method is a local optimization technique which uses multiple points distributed across the parameter space to find the optimum. Nelder Mead Simplex Algorithm is less dependent on the starting point than most local optimizers.

Suitable for: Complex problem domains with relatively few parameters, systems without a good initial model

Interpolated Quasi Newton

This is a fast local optimizer which uses interpolation to approximate the gradient of the parameter space. The Interpolated Quasi Newton method has fast convergence.

Suitable for: Computationally demanding models

Classic Powell

A simple, robust local optimizer for single-parameter problems. Although slower than the Interpolated Quasi Newton, it can sometimes be more accurate.

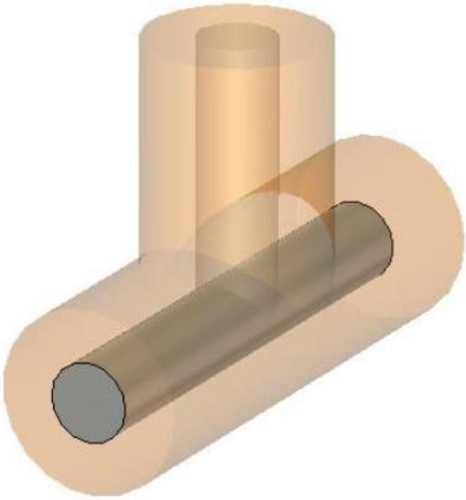
Suitable for: Single-variable optimization

Decap Optimization

A specialized optimizer for printed circuit board (PCB) design, the Decap Optimizer calculates the most effective placement of decoupling capacitors using the Pareto front method. This can be used to minimize either the number of capacitors needed or the total cost while still meeting the specified impedance curve.

Suitable for: PCB layout

Key Features for High Frequency Simulation



General

- Native graphical user interface based on Windows 7 (SP 1 or later), Windows 2008 Server R2 (SP 1 or later), Windows 8.1, Windows 2012 Server R2, Windows 10, Windows Server 2016 and Windows Server 2019
- The structure can be viewed either as a 3D model or as a schematic. The latter allows for easy coupling of EM simulation with circuit simulation.
- Various independent solver strategies (based on hexahedral as well as tetrahedral meshes) allow accurate results with a high performance for all kinds of high frequency applications.
- For specific solvers, highly advanced numerical techniques offer features like Perfect Boundary Approximation (PBA), Thin Sheet Technique (TST) or octree-based meshing for hexahedral grids and curved and higher order elements for tetrahedral meshes.

Structure Modeling

- Advanced ACIS-based, parametric solid modeling front end with excellent structure visualization
- Feature-based hybrid modeler allows quick structural changes
- Import of 3D CAD data from ACIS® SAT/SAB, CATIA®, SOLIDWORKS®, Autodesk Inventor, IGES, VDA-FS, STEP, PTC Creo, Siemens NX, Parasolid, Solid Edge, CoventorWare, Mecadtron, NASTRAN, STL or OBJ files
- Import of 2D CAD data from DXF™, GDSII and Gerber RS274X, RS274D files
- Import of EDA data from design flows including Cadence Allegro® / APD® / SiP®, Mentor Graphics Expedition®, Mentor Graphics PADS®, Mentor Graphics HyperLynx®, Zuken CR-5000® / CR-8000®, IPC-2581 and ODB++® (e.g. Altium Designer, Mentor Graphics Boardstation®, CADSTAR®, Visula®)
- Import of OpenAccess and GDSII-based integrated-circuit layouts via CST Chip Interface
- Import of PCB designs originating from CST PCB STUDIO®
- Import of 2D and 3D sub models

- Import of Sonnet® EM models, Cadence®, AWR®, Microwave Office® and Keysight Technologies ADS® layouts
- Import of a visible human model dataset or other voxel datasets
- Export of CAD data to ACIS SAT/SAB, IGES, STEP, NASTRAN, STL, DXF, GDSII, Gerber or POV files
- Parameterization for imported CAD files by using local modifications
- Material database
- Structure templates for simplified problem setup

Transient Solver

- Fast and memory efficient Finite Integration Technique (FIT)
- Efficient calculation for loss-free and lossy structures
- Direct time-domain analysis and broadband calculation of S-parameters from one single calculation run by applying DFTs to time signals
- Possibility to suppress the disk storage of time signals
- Calculation of field distributions as a function of time or at multiple selected frequencies from one simulation run
- Solver stop criteria based on S-parameters, radiated power and probe results
- Adaptive mesh refinement in 3D using S-Parameter or 0D results as stop criteria
- Shared memory parallelization of the transient solver run and of the matrix calculator
- MPI Cluster parallelization via domain decomposition
- Support of hardware acceleration (selected NVIDIA and AMD GPUs)
- Combined simulation with MPI and hardware acceleration
- Support of Linux batch mode and batch queuing systems (e.g. Slurm, PBS Pro, LSF, SGE) including native shell support
- Support of more than 2 billion mesh cells (with MPI)
- Isotropic and anisotropic material properties
- Frequency dependent material properties with arbitrary order for permittivity and permeability as well as a material parameter fitting functionality
- Gyrotropic materials (magnetized ferrites) as well as field-dependent microwave plasma
- Non-linear material models (Kerr, Raman)
- Spatially varying material models (general or with specialized radial dependency) with optional dispersive behavior and 3D material monitors
- Surface impedance models (tabulated surface impedance, Ohmic sheet, lossy metal, corrugated wall, material coating, metal surface roughness)
- Frequency dependent thin panel materials defined based on a multilayered stackup or an S-Matrix table (isotropic and symmetric)
- Special perforation materials like wire mesh and air ventilation panels (isotropic)
- Time dependent conductive materials (volumetric or lossy metal type)
- Temperature dependent materials with coupling to the Thermal or CHT solver from CST Studio Suite as well as to the Abaqus Solver (on irregular grid)
- Port mode calculation by a 2D eigenmode solver in the frequency domain
- Selective calculation of higher order port modes
- Automatic waveguide port mesh adaptation with optional result re-usage of identical ports
- Multipin and single-ended ports for (Q)TEM mode ports with multiple conductors
- Broadband treatment of inhomogeneous ports
- Multiport and multimode excitation (sequentially or simultaneously)

- PEC or PMC shielding functionality for waveguide ports
- Plane wave excitation (linear and broadband circular or elliptical polarization)
- Excitation by external nearfield sources imported from CST Studio Suite or Sigrity® tools or NFS nearfield scan data.
- Online TDR analysis with Gaussian or rectangular shape excitation function
- User defined excitation signals and signal database
- Simultaneous port excitation with different excitation signals for each port and broadband phase shift
- Single port excitation with user definable amplitude and phase setting
- Transient EM/circuit co-simulation with network elements
- AC radiation or irradiation cable co-simulation
- Transient radiation, irradiation or bi-directional cable co-simulation
- S-parameter symmetry option to decrease solve time for many structures
- Auto-regressive filtering for efficient treatment of strongly resonating structures
- Re-normalization of S-parameters for specified port impedances
- Phase de-embedding of S-parameters
- Inhomogeneous port accuracy enhancement for highly accurate S-parameter results, considering also low loss dielectrics
- Single-ended S-parameter calculation
- Possibility to use waveguide ports as mode monitors only
- S-parameter sensitivity and yield analysis
- Combined linear and logarithmic sampling of 1D spectral results
- High performance radiating/absorbing boundary conditions
- Conducting wall boundary conditions
- Periodic boundary conditions without phase shift
- Calculation of various electromagnetic quantities such as electric fields, magnetic fields, surface currents, power flows, current densities, power loss densities, electric energy densities, magnetic energy densities, voltages or currents in time and frequency domain
- 1D power loss results (time and frequency domain) per material or solid
- Calculation of time averaged power loss volume monitors
- Antenna farfield calculation (including gain, beam direction, side lobe suppression, etc.) with and without farfield approximation at multiple selected frequencies
- Broadband farfield monitors and farfield probes to determine broadband farfield information over a wide angular range or at certain angles
- Antenna array farfield calculation
- Radar Cross Section (RCS) calculation
- Calculation of Specific Absorption Rate (SAR) distributions
- Export of field source monitors, which then may be used as excitation for other high frequency solvers inside CST Studio Suite
- Discrete edge and face elements (lumped resistors) as ports
- Ideal voltage and current sources for EMC problems
- Discrete edge and face R, L, C, and (nonlinear) diode lumped elements at any location in the structure
- General lumped element circuit import from SPICE or Touchstone files
- Visualization of discretized wire endpoint connectivity
- Automatic parameter studies using built-in parameter sweep tool
- Automatic structure optimization for arbitrary goals using built-in optimizer

- Uni- and bi-directionally coupled simulations from CST Studio Suite with the Thermal or CHT solver
- Coupled simulations from CST Studio Suite with Abaqus' thermal solver
- Network distributed computing for optimizations, parameter sweeps and multiple port/mode excitations

TLM Solver

- Time domain Transmission-Line Matrix (TLM) method with octree-based meshing
- Efficient calculation for loss-free and lossy structures
- Direct time-domain analysis and broadband calculation of S-parameters from one single calculation run by applying DFTs to time signals
- Applicable to EMC/EMI applications such as radiated and conducted emissions and immunity, EMP and lightning, electrostatic discharge (ESD), high speed interference and shielding analysis
- Solver stop criteria based on S-parameters, radiated power and probe results
- Support of GPU acceleration
- Isotropic and anisotropic materials (including materials with axes not aligned to the mesh)
- Frequency dependent material properties with arbitrary order for permittivity and permeability as well as a material parameter fitting functionality
- Gyrotropic materials with homogeneous biasing field
- Frequency dependent thin panel materials defined based on a multilayered stackup or an S-Matrix table
- Special perforation materials like wire mesh and air ventilation panels
- User defined excitation signals and signal database
- Simultaneous port excitation with different excitation signals for each port and broadband phase shift
- Transient EM/circuit co-simulation with network elements
- AC radiation or irradiation cable co-simulation
- Transient radiation, irradiation or bi-directional cable co-simulation
- Excitation by external nearfield sources imported from CST Studio Suite or Sigrity® tools or NFS nearfield scan data.
- Compact models which avoid excessively fine meshes for:
- slots, seams and gaskets
- multi-conductor wires
- conductive coatings and absorbers
- Broadband compact antenna radiation sources based on the Equivalence Principle
- Calculation of various electromagnetic quantities such as electric fields, magnetic fields, surface currents, power flows, current densities, power loss densities, electric energy densities, magnetic energy densities, voltages or currents in time and frequency domain
- 1D power loss results (time and frequency domain) per material or solid
- Calculation of time averaged power loss monitors
- Antenna farfield calculation (including gain, beam direction, etc.)
- Broadband farfield monitors and farfield probes to determine broadband farfield information over a wide angular range or at certain angles
- Radar Cross Section (RCS) calculation
- Calculation of Specific Absorption Rate (SAR) distributions

- Export of field source monitors, which then may be used as excitation for other high frequency solvers inside CST Studio Suite
- Cylinder scan for emissions analysis yielding peak radiated fields vs. frequency
- Discrete edge or face elements (lumped resistors) as ports
- Ideal voltage and current sources for EMC problems
- Lumped R, L, C elements at any location in the structure
- Visualization of discretized wire endpoint connectivity

Frequency Domain Solver

- Efficient calculation for loss-free and lossy structures
- Support of hexahedral meshes as well as linear and curved tetrahedral meshes
- Adaptive mesh refinement in 3D using various stopping criteria: S-parameters or probe results at multiple frequency points, broadband S-parameters, as well as 0D and 1D result templates
- Special mesh refinement for singular edges
- True Geometry Adaptation
- Option to maintain the tetrahedral mesh during optimization and parameter sweep with small geometric changes
- Fast broadband adaptive frequency sweep for S-parameters and field probes
- Equidistant, logarithmic and user defined frequency sweeps and evaluation for 1D results
- Continuation of the solver run with additional frequency samples
- Low frequency stabilization
- Direct and iterative matrix solvers with convergence acceleration techniques
- Higher order representation of the fields, with either constant or variable order (with tetrahedral mesh)
- Support of Linux batch mode and batch queuing systems (e.g. OGE, LSF)
- Isotropic and anisotropic material properties
- Arbitrary frequency dependent material properties (general purpose sweep with tetrahedral mesh)
- Surface impedance model for good conductors, Ohmic sheets and corrugated walls, as well as frequency-dependent, tabulated surface impedance data and coated materials (with tetrahedral mesh)
- Inhomogeneously biased ferrites with a static biasing field (general purpose sweep with tetrahedral mesh), based on SAM (System and Assembly Modeling)
- Temperature dependent materials with coupling to the Thermal or CHT solver from CST Studio Suite
- Uni- and bi-directionally coupled simulations with the Thermal or CHT solver from CST Studio Suite
- Coupled simulations with the Stress Solver from CST Studio Suite
- Port mode calculation by a 2D eigenmode solver in the frequency domain
- Automatic waveguide port mesh adaptation (with tetrahedral mesh)
- Multipin ports for TEM modes in ports with multiple conductors
- Simultaneous excitation with individual amplitude and phase shift settings for selected excitations (with tetrahedral mesh)
- PEC or PMC shielding functionality for waveguide ports
- Plane wave excitation with linear, circular or elliptical polarization (with tetrahedral mesh), as well as plane waves in layered dielectrics (general purpose sweep)

- Discrete edge and face elements (lumped resistors) as ports (face elements with tetrahedral mesh, numerical face port solver for arbitrary shaped geometries with general purpose sweep)
- Ideal current source for EMC problems (general purpose sweep with tetrahedral mesh)
- Nearfield source imprint on open boundaries, lossy metal, and Ohmic sheets (general purpose sweep with tetrahedral mesh)
- Lumped R, L, C elements at any location in the structure
- Arbitrary shaped lumped elements (general purpose sweep with tetrahedral mesh)
- General lumped element circuit import from SPICE and Touchstone files (general purpose sweep with tetrahedral mesh)
- Re-normalization of S-parameters for specified port impedances
- Phase de-embedding of S-parameters
- Single-ended S-parameter calculation, with native single-ended field monitors for tetrahedral mesh
- S-parameter sensitivity and yield analysis (with tetrahedral mesh)
- High performance radiating/absorbing boundary conditions
- Conducting wall boundary conditions (with tetrahedral mesh)
- Periodic boundary conditions including phase shift or scan angle
- Unit cell feature to simplify the simulation of periodic antenna arrays or of frequency selective surfaces (general purpose sweep)
- Convenient generation of the unit cell calculation domain from arbitrary structures (with tetrahedral mesh)
- Floquet mode ports (periodic waveguide ports)
- Fast farfield calculation based on the Floquet port aperture fields (general purpose sweep with tetrahedral mesh)
- Calculation of various electromagnetic quantities such as electric fields, magnetic fields, surface currents, power flows, current densities, surface and volumetric power loss densities, electric energy densities, magnetic energy densities
- Antenna farfield and farfield probe calculation (including gain, beam direction, side lobe suppression, etc.) with and without farfield approximation
- Antenna array farfield calculation
- RCS calculation (with tetrahedral mesh)
- Calculation of SAR distributions (with hexahedral mesh)
- Export of field source monitors (with tetrahedral mesh), which then may be used as excitation for other high frequency solvers inside CST Studio Suite
- Export of fields for corona discharge and multipactor analysis with Spark3D (tetrahedral mesh only)
- Automatic parameter studies using built-in parameter sweep tool
- Automatic structure optimization for arbitrary goals using built-in optimizer
- Network distributed computing for optimizations and parameter sweeps
- Network distributed computing for frequency samples and remote calculation
- MPI Cluster parallelization via domain decomposition (general purpose sweep with tetrahedral mesh)
- Option to define repetitions of domains with the domain decomposition solver, for instance to efficiently simulate antenna arrays
- Besides the general purpose frequency sweep, a fast reduced order model technique, specifically designed for the efficient calculation of broadband results such as S-parameters, field probes and far-field probes, is available.

Integral Equation Solver

- Broadband calculation of S-parameters also for near- and farfield excitations
- Calculation of various electromagnetic quantities such as electric fields, magnetic fields, surface currents
- Antenna farfield calculation (including gain, beam direction, side lobe suppression, etc.)
- RCS calculation
- Fast monostatic RCS sweep
- Characteristic Mode Analysis (including modal weighting coefficient calculation)
- Supports antenna coupling workflow
- Export of field source monitors, which then may be used as excitation for other high frequency solvers inside CST Studio Suite
- Waveguide port excitation
- Plane wave excitation
- Nearfield source excitation
- Farfield source excitation
- Farfield source excitation with multipole coefficient calculation
- Receiving farfield source and nearfield source excitation
- Current distribution
- Discrete edge and face port excitation
- Face lumped R, L, C elements
- Symmetries are supported for discrete ports, waveguide ports, plane wave and farfield excitations.
- MPI parallelization for MLFMM and direct solver
- Support of GPU acceleration for MLFMM and direct solver
- Support of combined MPI & GPU acceleration
- Support of Linux batch mode and batch queuing systems (e.g. OGE, LSF)
- Infinite electric and magnetic ground planes
- Infinite Real Ground option
- Multithread parallelization
- Efficient calculation of loss-free and lossy structures including lossy waveguide ports
- Surface mesh discretization (triangles and quadrilaterals)
- Wire mesh discretization with special junction meshing strategy
- Support of Curved Mesh (quadrilateral and triangular surface mesh elements)
- Handling of layered media, which enables simulation of windshield antennas etc.
- Support of isotropic and layered thin-panel, which enables simulation of radomes, etc.
- Isotropic material properties
- Coated materials
- Arbitrary frequency dependent material properties
- Surface impedance models (tabulated surface impedance, Ohmic sheet, lossy metal)
- Automatic fast broadband adaptive frequency sweep
- User defined frequency sweeps
- Low frequency stabilization
- Direct and iterative matrix solvers with convergence acceleration techniques
- Higher order representation of the fields including mixed order
- Single and double precision floating-point representation
- Port mode calculation by a 2D eigenmode solver in the frequency domain
- Automatic waveguide port mesh adaptation

- Simultaneous excitation with individual amplitude and phase shift settings for selected excitations
- Re-normalization of S-parameters for specified port impedances
- Phase de-embedding of S-parameters
- Automatic parameter studies using built-in parameter sweep tool
- Automatic structure optimization for arbitrary goals using built-in optimizer
- Network distributed computing for optimizations and parameter sweeps
- Network distributed computing for frequency sweeps

Multilayer Solver

- Broadband calculation of S-parameters
- Calculation of various electromagnetic quantities such as electric fields, magnetic fields, surface currents
- Waveguide (multipin) port excitation
- Discrete face port excitation
- Plane wave excitation
- Characteristic Mode Analysis (including modal weighting coefficient calculation)
- Face lumped R, L, C elements
- Multithread parallelization
- MPI parallelization for the direct solver
- Efficient calculation of loss-free and lossy structures
- Surface mesh discretization (curved triangles and quadrilaterals)
- Support of Curved Mesh (quadrilateral and triangular surface mesh elements)
- Automatic edge mesh refinement is available for finite-thickness and infinitely thin conductors
- Isotropic material properties
- Arbitrary frequency dependent material properties
- Automatic fast broadband adaptive frequency sweep
- User defined frequency sweeps
- Re-normalization of S-parameters for specified port impedances
- Phase de-embedding of S-parameters
- Simultaneous excitation with individual amplitude and phase shift settings for selected excitations
- Automatic parameter studies using built-in parameter sweep tool
- Automatic structure optimization for arbitrary goals using built-in optimizer
- Network distributed computing for optimizations and parameter sweeps
- Network distributed computing for frequency sweeps

Asymptotic Solver

- Specialized tool for fast monostatic and bistatic RCS sweeps and antenna farfield calculations
- Fast ray tracing technique including multiple reflections and edge diffraction (SBR) by using either independent rays or ray-tubes
- Supports antenna coupling workflow
- Field of view analysis
- Multiple plane wave excitations with different polarization types

- Farfield source excitation
- Nearfield source excitation
- Receiving farfield source and nearfield source excitation
- Robust surface mesh discretization including curved meshes
- PEC and vacuum material properties
- Complex surface impedance materials
- Coated materials (incl. frequency dependent and angle dependent properties)
- Thin dielectrics (incl. frequency dependent and angle dependent properties)
- Solid lossless dielectrics
- User defined frequency sweeps and angular sweeps
- Visualization of rays and their amplitudes, including multiple reflections
- Visualization of points where the rays initially hit the structure
- Computation of range profiles, sinograms, and ISAR-images
- Computation of scattering hotspots
- Computation of RCS maps
- Tabulated export of raw solver data
- Calculation of electric and magnetic fields
- Export of field source monitors, which then may be used as excitation for other high frequency solvers inside CST Studio Suite
- Multithread parallelization
- Support of GPU acceleration for field sources and bistatic calculations
- Automatic parameter studies using built-in parameter sweep tool
- Automatic structure optimization for arbitrary goals using built-in optimizer
- Network distributed computing for optimizations and parameter sweeps
- Network distributed computing for excitation angles
- Network distributed computing for near- and farfield sources

Eigenmode Solver

- Calculation of modal field distributions in closed or open structures, with and without consideration of losses
- Support of hexahedral meshes as well as linear and curved tetrahedral meshes
- Isotropic and anisotropic materials
- Multithread parallelization
- Adaptive mesh refinement in 3D, with True Geometry Adaptation
- Open, conducting wall, and periodic boundary conditions including phase shift
- Accurate calculation of losses and internal or external Q-factors for each mode (directly or using a perturbation method)
- Discrete L, C elements at any location in the structure
- Target frequency can be set (calculation within the frequency interval)
- Calculation of all eigenmodes in a given frequency interval
- Sensitivity analysis with respect to materials and geometric deformations defined by face constraints (with tetrahedral mesh)
- Automatic parameter studies using built-in parameter sweep tool
- Automatic structure optimization for arbitrary goals using built-in optimizer
- Network distributed computing for optimizations and parameter sweeps
- Uni-directionally coupled simulations with the Thermal Solver from CST Studio Suite

- Coupled simulations with the Stress Solver from CST Studio Suite
- Export of fields for corona discharge and multipactor analysis with Spark3D (tetrahedral mesh only)

Schematic View

- The schematic view shows the circuit level description of the current high frequency simulation project
- Allows additional wiring, including active and passive circuit elements as well as more complex circuit models coming from measured data (e.g. Touchstone or IBIS files), analytical or semi analytical descriptions (e.g. microstrip or stripline models) or from simulated results (CST Studio Suite projects)
- Offers many different circuit simulation methods, including transient EM/circuit co-simulations
- All schematic elements as well as all defined parameters of the connected high frequency simulation project can be parameterized and are ready for optimization runs
- Geometry creation by assembling the components on the schematic in 3D
- Flexible and powerful hierarchical task concept offering nested parameter sweep / optimizer setups
- Recombination of 3D fields for stimulations calculated by the circuit simulator

SAM (System Assembly and Modeling)

- 3D representations for individual components
- Automatic project creation by assembling the schematic's elements into a full 3D representation
- Fast parametric modeling front end for easy component transformation and alignment
- Manage project variations derived from one common 3D geometry setup
- Coupled Multiphysics simulations by using different combinations of coupled circuit/EM/thermal/mechanical projects
- Hybrid Solver Task (uni- or bi-directional coupling of 3D high frequency solvers)
- Antenna Array Task

Visualization and Secondary Result Calculation

- Multiple 1D result view support
- Displays S-parameters in xy-plots (linear or logarithmic scale)
- Displays S-parameters in Smith charts and polar charts
- Online visualization of intermediate results during simulation
- Import and visualization of external xy-data
- Copy / paste of xy-datasets
- Fast access to parametric data via interactive tuning sliders
- Automatic parametric 1D result storage
- Displays port modes (with propagation constant, impedance, etc.)
- Various field visualization options in 2D and 3D for electric fields, magnetic fields, power flows, surface currents, etc.
- Animation of field distributions

- Calculation and display of farfields (fields, gain, directivity, RCS) in xy-plots, polar plots, scattering maps, radiation plots (3D)
- Nearfield cylinder scan visualization
- Calculation of Specific Absorption Rate (SAR) including averaging over specified mass
- Calculation of surface losses by perturbation method and of the Q factor
- Display and integration of 2D and 3D fields along arbitrary curves
- Integration of 3D fields across arbitrary faces
- Automatic extraction of SPICE network models for arbitrary topologies ensuring the passivity of the extracted circuits
- Combination of results from different port excitations
- Hierarchical result templates for automated extraction and visualization of arbitrary results from various simulation runs. These data can also be used for the definition of optimization goals.

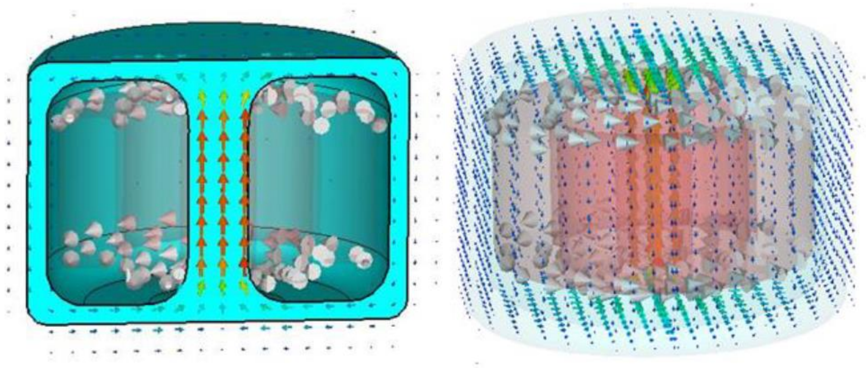
Result Export

- Export of S-parameter data as Touchstone files
- Export of result data such as fields, curves, etc. as ASCII files
- Export screen shots of field plots
- Export of farfield data as excitation for integral equation or asymptotic solver
- Export of frequency domain nearfield data from transient or frequency domain solver, for use as excitation in transient solver

Automation

- Powerful VBA (Visual Basic for Applications) compatible macro language including editor and macro debugger
- CST Python Libraries to control solvers, access 0D/1D results, provide an interface to Printed Circuit Board data and more
- OLE automation for seamless integration into the Windows environment (Microsoft Office®, MATLAB®, AutoCAD®, MathCAD®, Windows Scripting Host, etc.)

CST EM Studio Key Features



General

- Native graphical user interface based on Windows 7, Windows 2008 Server R2, Windows 8, Windows 2012 Server, Windows 8.1, Windows 2012 Server R2 or Windows 10
- The structure can be viewed either as a 3D model or as a schematic. The latter allows for easy coupling of EM simulation with circuit simulation.
- Various independent types of solver strategies (based on hexahedral as well as tetrahedral meshes) allow accurate results with a high performance for all kind of low frequency applications.
- For specific solvers, highly advanced numerical techniques offer features like PERFECT BOUNDARY APPROXIMATION (PBA)® for hexahedral grids and curved and higher order elements for tetrahedral meshes.

Structure Modeling

- Advanced ACIS-based, parametric solid modeling front end with excellent structure visualization
- Feature-based hybrid modeler allows quick structural changes.
- Import of 3D CAD data from ACIS SAT (e.g. AutoCAD®), ACIS SAB, Autodesk Inventor®, IGES, VDA-FS, STEP, Pro/ENGINEER®, CATIA®, Siemens NX, Parasolid, Solid Edge, SolidWorks, CoventorWare®, Mecadtron®, NASTRAN, STL or OBJ files
- Import of 2D CAD data from DXF™, GDSII and Gerber RS274X, RS274D files
- Import of EDA data from design flows including Cadence Allegro® / APD® / SiP®, Mentor Graphics Expedition®, Mentor Graphics PADS®, Mentor Graphics HyperLynx®, Zuken CR-5000® / CR-8000®, IPC-2581 and ODB++® (e.g. Altium Designer, Mentor Graphics Boardstation®, CADSTAR®, Visula®)
- Import of OpenAccess and GDSII-based integrated-circuit layouts via CST Chip Interface
- Import of PCB designs originating from CST PCB Studio®
- Import of 2D and 3D sub models
- Import of Agilent ADS® layouts
- Import of Sonnet® EM models
- Import of a visible human model dataset or other voxel datasets
- Export of CAD data by ACIS SAT, ACIS SAB, IGES, STEP, NASTRAN, STL, DXF™, GDSII, Gerber or POV files
- Parameterization for imported CAD files
- Material database
- Structure templates for simplified problem setup

Electrostatic Solver

- Isotropic and (coordinate-dependent) anisotropic material properties
- Support of hexahedral meshes as well as linear and curved tetrahedral meshes
- Sources: potentials, charges on conductors (floating potentials), uniform volume- and surface-charge densities, capacitive field grading
- Force calculation
- Capacitance calculation
- Electric / magnetic / tangential / normal / open / fixed-potential boundary-conditions

- Perfect conducting sheets and wires
- Discrete edge capacitive elements at any location in the structure
- Adaptive mesh refinement in 3D
- Higher order representation of the solution with tetrahedral mesh
- Automatic parameter studies using built-in parameter sweep tool
- Automatic structure optimization for arbitrary goals using built-in optimizer
- Network distributed computing for optimizations, parameter sweeps and remote calculations
- Coupled simulations with Mechanical Solver from CST MPhysics Studio®
- Equivalent Circuit EMS/DS Co-Simulation for constant material properties

Magnetostatic Solver

- 3D- and 2D1- problem support.
- Isotropic and (coordinate-dependent) anisotropic material properties
- Nonlinear ferromagnetic material properties
- Laminated material properties
- Support of hexahedral meshes as well as linear and curved tetrahedral meshes
- Sources: coils, coil segments including those created from solids, linear and non-linear permanent magnets, current paths, external magnetic fields, stationary current fields, current ports
- Force and force density calculation
- Apparent and incremental inductance calculation
- Flux linkages
- Electric / magnetic / tangential / normal / open / subvolume boundary-conditions
- Rotational periodicity for 2D and 3D problems
- Adaptive mesh refinement for 2D and 3D solver
- Higher order representation of the solution with tetrahedral and triangular meshes
- Automatic parameter studies using built-in parameter sweep tool
- Automatic structure optimization for arbitrary goals using built-in optimizer
- Network distributed computing for optimizations, parameter sweeps and remote calculations
- Coupled simulations with Mechanical Solver from CST MPhysics Studio
- Equivalent Circuit EMS/DS Co-Simulation for constant and nonlinear material properties

Stationary Current Solver

- Isotropic and (coordinate-dependent) anisotropic material properties
- Nonlinear electrical conductivity properties
- Temperature dependent materials with coupling to CST MPhysics Studio
- Electric contact resistance
- Support of hexahedral meshes as well as linear and curved tetrahedral meshes
- Sources: current paths, potentials, current ports, coil segments including those created from solids
- Conductance calculation
- Discrete edge resistances at any location in the structure

- Perfect conducting sheets and wires
- Electric / magnetic / normal / tangential / subvolume boundary-conditions
- Adaptive mesh refinement in 3D
- Higher order representation of the solution with tetrahedral mesh
- Automatic parameter studies using built-in parameter sweep tool
- Automatic structure optimization for arbitrary goals using built-in optimizer
- Network distributed computing for optimizations, parameter sweeps and remote calculations
- Uni- and bi-directionally coupled simulations with the Thermal and CHT Solvers from CST MPhysics Studio
- Equivalent Circuit EMS/DS Co-Simulation for constant material properties

LF Frequency Domain Solver

- Isotropic and (coordinate-dependent) anisotropic material properties
- Nonlinear material properties (B(H)) and linear equivalent permeability computation
- Temperature dependent nonlinear (B(H)) and linear materials with coupling to CST MPhysics Studio
- Support of hexahedral meshes as well as linear and curved tetrahedral meshes
- Electroquasistatic analysis
- Magnetoquasistatic analysis (eddy current approximation)
- Full wave analysis
- Sources for electroquasistatic analysis: potentials
- Sources for full wave and magnetoquasistatic analysis: coils, coil segments including those created from solids, current ports, current paths, voltage paths, external magnetic source fields
- Impedance calculation
- Stable broadband impedance calculation for magnetoquasistatic analysis from zero frequency to given maximal frequency for the setups with stranded coils and segments, current ports and coil segments created from solids
- Broadband source parameters for magnetoquasistatic analysis for the setups with classical stranded coils, current ports and/or coil segments created from solids.
- Authoring of Reduced Order Models as Functional Mockup Units according to FMI standard
- Fast frequency sweep in the broadband solver regime
- Force calculation
- Perfect conducting sheets and wires
- Lumped R, L, C elements at any location in the structure
- Surface impedance model for good conducting metals
- Electric / magnetic / open boundary-conditions
- Adaptive mesh refinement in 3D
- Higher order representation of the solution with tetrahedral mesh
- Automatic parameter studies using built-in parameter sweep tool
- Automatic structure optimization for arbitrary goals using built-in optimizer
- Network distributed computing for optimizations, parameter sweeps and remote calculations
- Uni-directionally coupled simulations with the Thermal and CHT solvers from CST MPhysics Studio for both magnetoquasistatic and electroquasistatic analysis

- Bi-directionally coupled simulations with the Thermal and CHT solvers from CST MPhysics Studio for magnetoquasistatic analysis
- Coupled simulations with SIMULIA Abaqus

LF Time Domain Solver

- Isotropic and (coordinate-dependent) anisotropic material properties
- Magnetoquasistatic analysis (eddy current approximation), 3D- and 2D2-problem support
- Electroquasistatic analysis
- Nonlinear material properties (B(H), E(J), J(H, T))
- Recoil model for nonlinear hard magnetic material properties (permanent magnets)
- Iron Loss computation
- Support of linear and curved tetrahedral meshes
- Sources for the magnetoquasistatic analysis: coils, coil segments including those created from solids, current ports, current paths, voltage paths, permanent magnets, external magnetic source field
- Sources for electroquasistatic analysis: potentials
- Magnetoquasistatic analysis: perfect conducting sheets and wires
- Electric / magnetic / open / subvolume boundary-conditions
- Higher order representation of the solution with tetrahedral mesh
- User defined excitation signals and signal database
- Adaptive time stepping
- Dedicated time stepping algorithm for time periodic problems
- Rigid body motion for 2D and 3D models with nested rotations and translation
- Periodic boundary condition (translation) and subvolume (rotation)
- Demagnetization monitors
- Network distributed computing remote calculations
- Uni-directionally coupled simulations with the Thermal and CHT solvers from CST MPhysics Studio
- Coupled simulations with SIMULIA Abaqus

Partial RLC Solver

- Calculation of equivalent circuit parameters (partial inductances, resistances, and capacitances) and optional SPICE export
- For a detailed description consult the online documentation

CST Design Studio View

- Schematic view that shows the circuit level description of the current CST EM Studio project
- Allows additional wiring, including active and passive circuit elements as well as more complex circuit models coming from measured data (e.g. Touchstone or IBIS files), analytical or semi-analytical descriptions, or from simulated results (e.g. CST Microwave Studio, CST Cable Studio or CST PCB Studio projects)
- Offers many different circuit simulation methods

- All schematic elements as well as all defined parameters of the connected CST EM Studio project can be parameterized and are ready for optimization runs
- Geometry creation by assembling the components on the schematic in 3D
- Flexible and powerful hierarchical task concept offering nested parameter sweep / optimizer setups

SAM (System and Assembly Modeling)

- 3D representations for individual components
- Automatic project creation by assembling the schematic's elements into a full 3D representation
- Manage project variations derived from one common 3D geometry setup
- Coupled multi-physics simulations by using different combinations of coupled Circuit/EM/thermal/mechanical projects

Visualization and Secondary Result Calculation

- Multiple 1D result view support
- Online visualization of intermediate results during transient simulations
- Import and visualization of external xy-data
- Copy & paste of xy-datasets
- Fast access to parametric data via interactive tuning sliders
- Automatic parametric 1D result storage
- Various field visualization options in 2D and 3D for electric fields, magnetic fields, potentials, current densities, energy densities, etc.
- Animation of field distributions
- Display of source definitions in 3D
- Display of nonlinear material curves in xy-plots
- Display of material distribution for nonlinear materials
- Display and integration of 2D and 3D fields along arbitrary curves
- Integration of 3D fields across arbitrary faces
- Hierarchical result templates for automated extraction and visualization of arbitrary results from various simulation runs. These data can also be used for the definition of optimization goals.

Result Export

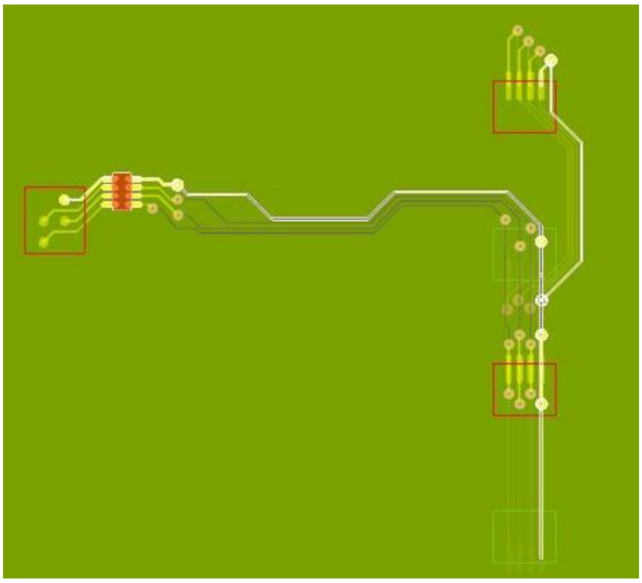
- Export of result data such as fields, curves, etc.
- Export of result data as ASCII files
- Export screen shots of result field plots

Automation

- Powerful VBA (Visual Basic for Applications) compatible macro language including editor and macro debugger

- OLE automation for seamless integration into the Windows environment (Microsoft Office®, MATLAB®, AutoCAD®, MathCAD®, Windows Scripting Host, etc.)

CST PCB Studio Key Features



General

- Native graphical user interface based on Windows operating systems.
- Tight interface to CST Design Studio.
- PEEC method specializing in the simulation of single- and two-layer boards.
- Transmission line modeling method for SI analysis of high-speed multi-layer PCBs and packages.
- Specialized FEM method for PI analysis of high-speed multi-layer PCBs and packages.
- IR-Drop analysis to simulate DC power/ground behavior of a PCB and package.

PCB Structure Modeling

- Import of PCB designs from Cadence Allegro/ADP/SiP.
- Import of PCB designs from Mentor Graphics Expedition.
- Import of PCB designs from Mentor Graphics Hyperlynx.
- Import of PCB designs from Mentor Graphics PADS.
- Import of PCB designs from Zuken C-R5000/8000 ASCII.
- Import of PCB designs from ODB++.
- PCB layout checker with automatic correction.
- Interactive PCB editing tools.
- Advanced navigation through the PCB.
- Hiding/visualizing selections.

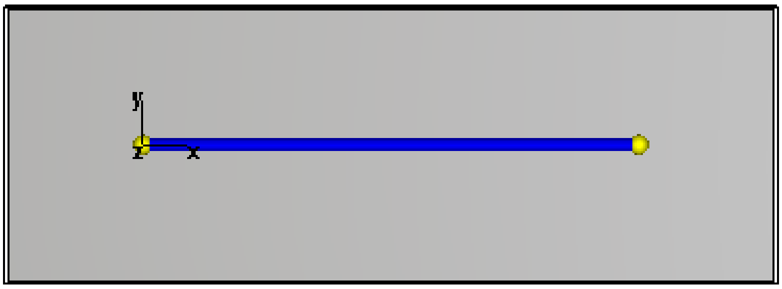
PCB Electric Modeling

- Automatic meshing and extraction of 3D PEEC models.
- Automatic meshing and extraction of 2D transmission line models.
- Automatic meshing and extraction of 3D (FE FD) models and PDN impedances.
- Consideration of skin-effect and dielectric loss in time and frequency domain.
- Export of equivalent SPICE circuits.
- Export of current distribution and near fields for radiation analysis.
- Advanced export of PCB sub structures to CST Microwave Suite.

Circuit Simulator

- Schematic editor enables the easy definition of passive and active devices.
- Fast circuit simulation in time and frequency domain.
- Support of IBIS models.
- Import and Export of S-Parameter data via TOUCHSTONE file format.
- Parameterization of termination circuitry and parameter sweep.

CST Cable Studio Key Features



General

- Native graphical user interface based on Windows operating systems.
- Tight interface to CST Design Studio and CST Microwave Studio enabling cable modeling, circuit simulation and 3D full-wave analysis in one environment.
- Transmission line modeling method for fast and accurate simulation of TEM / Quasi-TEM propagation modes inside complex cable structures.
- Hybrid method combining transmission line analysis with 3D “full-wave” analysis.

Harness Structure Modeling

- Easy definition of complex harness topology.
- Import of harness via NASTRAN and STEP AP212-KBL.
- Interactive cable editing dialog boxes for all relevant types of cables.
- Parameterization of cable position.

Harness Electric Modeling

- Automatic meshing and extraction of 2D transmission line parameters.
- Modelling of all relevant cable types in any combination (single wire, ribbon cables, twisted cables and shielded cables).
- Consideration of skin and proximity effects as well as dielectric loss in time and frequency domains.
- Consideration of transfer impedance for compact, foil or braided shields.
- Impedance calculator for characteristic line impedances.
- Export of equivalent SPICE circuits.

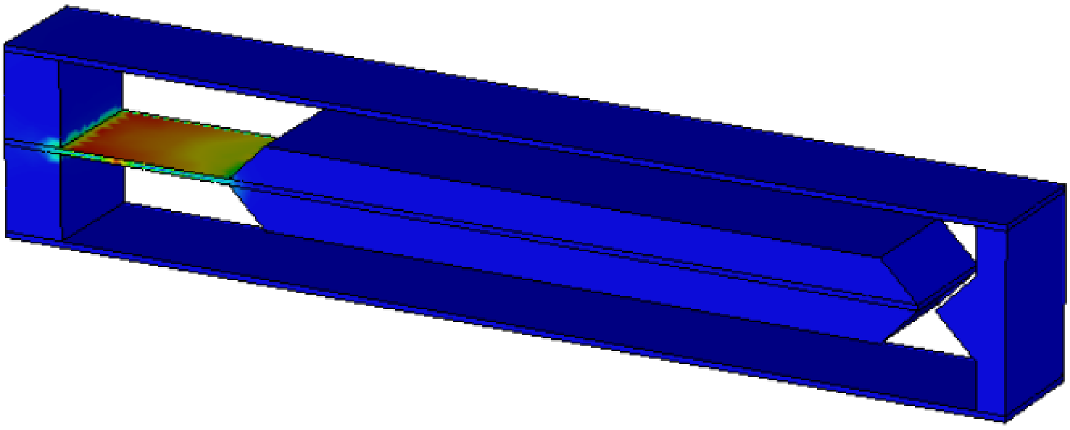
Circuit Simulator

- Schematic editor enables the easy definition of passive and active devices on the cable's equivalent circuit.
- Fast circuit simulation in time and frequency domains.
- Import of SPICE sub-circuits (Berkley SPICE syntax).
- Support of IBIS models.
- Import and Export of S-Parameter data via TOUCHSTONE file format.
- Parameterization of termination circuitry and parameter sweep.

3D Full-Wave Simulator

- Automatic transfer of impressed common mode currents on cable bundles from circuit simulator to the 3D "full-wave" simulator.
- Automatic transfer of induced voltages on cable bundles to circuit simulator.
- Advanced solid modelling to define scattering or antenna structures.
- Import of 3D CAD data by SAT, Autodesk Inventor®, IGES, VDA-FS, STEP, ProE®, CATIA 4®, CATIA 5®, CoventorWare®, Mecadtron®, NASTRAN or STL files to define scatter and antenna structures.
- Plane wave excitation (linear, circular, elliptical polarization).
- Ideal voltage and current sources for antenna excitation.
- Accurate and efficient time domain solvers, based on the Finite Integration Technique (FIT) and the Transmission-Line Matrix (TLM) method.
- Fully automatic creation of hexahedral grids in combination with the Perfect Boundary Approximation (PBA), Thin Sheet Technique (TST) and Octree-based meshing.
- Calculation of various electromagnetic fields and quantities such as electric fields, magnetic fields, surface currents and voltages.

CST MPhysics Studio Key Features



General

- Native graphical user interface based on Windows 7 (SP 1 or later), Windows 2008 Server R2 (SP 1 or later), Windows 8.1, Windows 2012 Server R2, Windows 10 and Windows Server 2016
- The structure can be viewed either as a 3D model or as a schematic. The latter allows for easy coupling of thermal simulation parameters with circuit simulation.
- Various independent types of solver strategies (based on hexahedral as well as tetrahedral meshes) allow accurate simulations with a high level of performance for a wide range of multi-physical applications.
- For specific solvers highly advanced numerical techniques offer features like Perfect Boundary Approximation® (PBA) for hexahedral grids and curved and higher order elements for tetrahedral meshes.

Structure Modeling

- Advanced ACIS-based, parametric solid modeling front end with excellent structure visualization
- Feature-based hybrid modeler allows quick structural changes
- Import of 3D CAD data from ACIS® SAT/SAB, CATIA®, SOLIDWORKS®, Autodesk Inventor, IGES, VDA-FS, STEP, PTC Creo, Siemens NX, Parasolid, Solid Edge, CoventorWare, Mecadtron, NASTRAN, STL or OBJ files
- Import of 2D CAD data by DXF, GDSII and Gerber RS274X, RS274D files
- Import of EDA data from design flows including Cadence Allegro® / APD® / SiP®, Mentor Graphics Expedition®, Mentor Graphics PADS®, Mentor Graphics HyperLynx®, Zuken CR-5000® / CR-8000®, IPC-2581 and ODB++® (e.g. Altium Designer, Mentor Graphics Boardstation®, CADSTAR®, Visula®)
- Import of PCB designs originating from CST PCB Studio®
- Import of 2D and 3D sub models
- Import of Agilent ADS® layouts
- Import of Sonnet® EM models
- Import of a visible human model dataset or other voxel datasets

- Export of CAD data to ACIS SAT/SAB, IGES, STEP, NASTRAN, STL, DXF, GDSII, Gerber or POV files
- Parameterization for imported CAD files
- Material database
- Structure templates for simplified problem setup

Mechanics Solver

- Temperature dependent Young's modulus
- Displacement boundary condition
- Traction boundary condition
- Thermal expansion
- Neo-Hookean material model for simulation of large deformations
- Various stress plots: von Mises, hydrostatic and tensor components
- Strain plots including visualization of the volumetric strain
- Nonlinear solver computes the Green-Lagrange and the Almansi-strain as well as the 2nd Piola-Kirchhoff and Cauchy stress tensors
- Displacement plot including visualization of deformed mesh
- Import of force densities from EM-solvers
- Export of deformed structure to CST Microwave Studio

Thermal Steady State Solver

- Isotropic and anisotropic material properties
- Bioheat material properties
- Nonlinear material properties (Bioheat properties and thermal conductivity)
- Thermal contact resistance
- Moving media
- Convection for human voxel models
- Heat transfer by conduction in volumes
- Heat transfer by convection and radiation through surfaces
- Sources: fixed and floating temperatures, heat sources, eddy current and stationary current loss fields, volume/surface power loss distributions in dielectric or lossy metal materials imported from CST Microwave Studio, CST EM Studio or CST PCB Studio, crashed particle loss distribution from CST Particle Studio
- Adiabatic / fixed or floating temperature / open boundary conditions
- Automatic parameter studies using built-in parameter sweep tool
- Automatic structure optimization for arbitrary goals using built-in optimizer
- Network distributed computing for optimizations, parameter sweeps and remote calculations
- Thermal conductance matrix calculation
- Equivalent Circuit EMS/MPS/DS Co-Simulation for linear problems

Thermal Transient Solver

- Isotropic and anisotropic material properties

- Bioheat material properties
- Nonlinear material properties (Bioheat properties, thermal conductivity and heat capacity)
- Thermal contact resistance
- Moving media
- Convection for human voxel models
- Heat transfer by conduction in volumes
- Heat transfer by convection and radiation through surfaces
- Sources: fixed, initial and floating temperatures, heat sources, eddy current and stationary current loss fields, volume/surface power loss distributions in dielectric or lossy metal materials imported from CST Microwave Studio, CST EM Studio or CST PCB Studio, crashed particle loss distribution from CST Particle Studio
- Adiabatic / fixed or floating temperature / open boundary conditions
- Low or high order time integration method, constant or adaptive time step width
- Network distributed computing for remote calculations
- Calculation of CEM43°C thermal dose in biological tissues

Conjugate Heat Transfer Solver

- Transient and steady-state solver for incompressible laminar or turbulent flows
- Conjugate heat transfer between solids and fluids
- Multi-fluid support for liquid cooling simulations
- Boussinesq approximation for buoyancy force in flows
- Surface-to-surface radiation with automatic calculation of view factors
- Opening: velocity- and pressure-based inlets and outlets
- Walls: slip/no slip, isothermal and adiabatic
- Internal inlet and outlets
- Internal heat sources
- External heat sources imported from CST Microwave Studio or CST EM Studio
- Axial fan model support
- Planar and volume flow resistance model support
- Two-resistor component model support
- Thermal contact properties: resistance, capacitance
- Thermal surface properties: surface emissivity and heat transfer coefficient
- Full GPU acceleration support

SAM (System and Assembly Modeling)

- 3D representations for individual components
- Automatic project creation by assembling the schematic’s elements into a full 3D representation
- Manage project variations derived from one common 3D geometry setup
- Coupled Multiphysics simulations by using different combinations of coupled circuit/EM/thermal/mechanical projects

Visualization and Secondary Result Calculation

- Online visualization of intermediate 1D results during simulation
- Import and visualization of external xy-data
- Copy / paste of xy-datasets
- Fast access to parametric data via interactive tuning sliders
- Automatic saving of parametric 1D results
- Multiple 1D result view support
- Various 2D and 3D field visualization options for thermal fields, heat flow densities, displacement fields, stress fields, etc.
- Animation of field distributions
- Display and integration of 2D and 3D fields along arbitrary curves
- Integration of 3D fields across arbitrary faces
- Hierarchical result templates for automated extraction and visualization of arbitrary results from various simulation runs. These data can also be used for the definition of optimization goals.

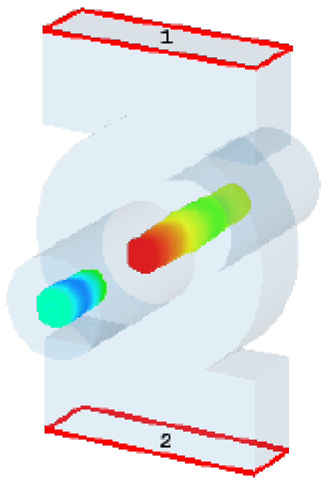
Result Export

- Export of result data such as fields, curves, etc. as ASCII files
- Export screen shots of result field plots

Automation

- Powerful VBA (Visual Basic for Applications) compatible macro language with editor and macro debugger
- OLE automation for seamless integration into the Windows environment (Microsoft Office®, MATLAB®, AutoCAD®, MathCAD®, Windows Scripting Host, etc.)

Key Features for Particle Dynamics Simulation



General

- Native graphical user interface based on Windows 7 (SP1 or later), Windows 2008 Server R2 (SP1 or later), Windows 8.1, Windows 2012 Server R2, Windows 10, Windows Server 2016 and Windows Server 2019
- The structure can be viewed either as a 3D model or as a schematic. The latter allows a parametrized approach of coupled simulation with our System Assembly and Modeling workflow.
- Various independent solver strategies allow accurate results with a high performance
- For specific solvers, highly advanced numerical techniques offer features like Perfect Boundary Approximation (PBA) ® for hexahedral grids and curved and higher order elements for tetrahedral meshes

Structure Modeling

- Advanced ACIS-based, parametric solid modeling front end with excellent structure visualization
- Feature-based hybrid modeler allows quick structural changes
- Import of 3D CAD data from ACIS SAT (e.g. AutoCAD®), ACIS SAB, Autodesk Inventor®, IGES, VDA-FS, STEP, Pro/ENGINEER®, CATIA®, Siemens NX, Parasolid, Solid Edge, SolidWorks, CoventorWare®, Mecadtron®, NASTRAN, STL or OBJ files
- Import of 2D CAD data from DXF™, GDSII and Gerber RS274X, RS274D files
- Import of EDA data from design flows including Cadence Allegro® / APD® / SiP®, Mentor Graphics Expedition®, Mentor Graphics PADS®, Mentor Graphics HyperLynx®, Zuken CR-5000® / CR-8000® and ODB++® (e.g. Mentor Graphics Boardstation®, CADSTAR®, Visula®)
- Import of PCB designs originating from CST PCB Studio®
- Import of 2D and 3D sub models
- Import of Agilent ADS® layouts
- Import of Sonnet® EM models
- Import of a visible human model dataset or other voxel datasets
- Export of CAD data to ACIS SAT, ACIS SAB, IGES, STEP, NASTRAN, STL, DXF™, GDSII, Gerber or POV files
- Parameterization for imported CAD files
- Material database
- Structure templates for simplified problem setup

Particle Tracking Simulator

- Arbitrary shaped particle source surfaces
- Circular particle sources with spatially inhomogeneous current distribution
- Particle interfaces for coupling of tracking/tracking or tracking/PIC simulations
- ASCII emission data imports based on particle interfaces
- Static-, eigenmode- and multiple external field distributions as source fields
- Support for hexahedral as well as linear and curved tetrahedral meshes
- Import of tetrahedral and hexahedral source fields into simulations

- Space charge limited, plasma-sheath, thermionic, fixed and field-induced emission model
- Oblique emission
- Secondary electron emission induced by ions or electrons as material property
- Optically stimulated electron emission
- Definable material transparency of sheets for particles
- Consideration of space charge via gun iteration
- Consideration of self-magnetic fields in gun iteration
- Analysis of extracted particle current and space charge
- Monitoring of beam cross-section, phase-space diagram and other statistical data of the beam
- Emittance calculation
- Thermal coupling (export of thermal loss distribution from crashed particles)
- Automatic parameter studies using built-in parameter sweep tool
- Automatic structure optimization for arbitrary goals using built-in optimizer
- Network distributed computing for remote computations
- Coupled simulations with the Thermal Solver from CST Studio Suite
- Support of Linux batch mode

Electrostatic Particle-in-Cell Simulator

- Arbitrary shaped particle source surfaces
- Circular particle sources with spatially inhomogeneous current distribution
- Volumetric particle source featuring Maxwellian distribution
- Particle interfaces for coupling of tracking/tracking or tracking/PIC simulations
- ASCII emission data imports based on particle interfaces
- Static-, eigenmode- and multiple external field distributions as source fields
- Support for hexahedral as well as linear and curved tetrahedral meshes
- Import of tetrahedral and hexahedral source fields intsimulations
- Gaussian-, DC-, field induced- and explosive emission model
- Oblique emission
- Secondary electron emission induced by ions or electrons as material property
- Monte-Carlcollision modelling:
    - Volume ionization due telectron impact
    - Neutral atom excitation due telectrons
    - Elastic collisions between electrons and neutral gas
    - Elastic collisions between ions and neutral gas
- Definable material transparency of sheets for particles
- Analysis of extracted particle current and space charge
- User defined excitation signals and signal database
- Monitoring of beam cross-section, phase-space diagram and other statistical data of the beam
- Particle Monitors on Solids or Boundaries including Energy Histogram
- Phase space monitoring
- Thermal coupling (export of thermal loss distribution from crashed particles)
- Online visualization of intermediate results during simulation
- Periodic boundary conditions for particles and the hexahedral field solver
- Automatic parameter studies using built-in parameter sweep tool

- Automatic structure optimization for arbitrary goals using built-in optimizer
- Network distributed computing for remote computations
- Coupled simulations with the Thermal Solver from CST StudiSuite
- Support of Linux batch mode
- Single-GPU acceleration for hexahedral meshes (not all solver features are supported)

Particle-in-Cell Simulator

- Arbitrary shaped particle source surfaces
- Circular particle sources with spatially inhomogeneous current distribution
- Circular particle source in open boundaries
- Volumetric particle source featuring Maxwellian distribution
- Gaussian-, DC-, field induced- and explosive emission model
- Oblique emission
- Particle interfaces for coupling of tracking and PIC simulations
- ASCII emission data imports based on particle interfaces
- Selection of active Particle Sources
- Static-, eigenmode- and multiple external field distributions as additional source fields
- Import of tetrahedral source fields
- Automatic detection of multipaction breakdown
- Thermal coupling (export of thermal loss distribution from crashed particles)
- Periodic boundary conditions for particles
- Support for Single- / Multi-GPU acceleration
- Single node parallelization
- Support of Linux batch mode
- Online visualization of intermediate results during simulation
- Calculation of field distributions as a function of time or at multiple selected frequencies from one simulation run
- Time domain monitoring of particle position and momentum
- Particle Monitors on Solids or Boundaries including Energy Histogram
- Time domain monitoring of output power
- Time domain monitoring of particle current density
- Phase space monitoring
- Emittance calculation
- Secondary electron emission induced by ions or electrons as material property
- Volume ionization based on Monte-Carlo collision model
- Definable material transparency of sheets for particles
- Isotropic and anisotropic material properties
- Frequency dependent material properties with arbitrary order for permittivity and permeability as well as a material parameter fitting functionality
- Field-dependent microwave plasma and gyrotropic materials (magnetized ferrites)
- Non-linear material models (Kerr, Raman)
- Surface impedance models (tabulated surface impedance, Ohmic sheet, lossy metal, corrugated wall, material coating)
- Frequency dependent multilayered thin panel materials (isotropic and symmetric)
- Time dependent conductive materials
- Port mode calculation by a 2D eigenmode solver in the frequency domain
- Efficient calculation of higher order port modes by specifying target frequency

- Automatic waveguide port mesh adaptation
- Multipin ports for TEM mode ports with multiple conductors
- User defined excitation signals and signal database
- Charge absorbing open boundaries for CPU solver
- High performance radiating/absorbing boundary conditions
- Conducting wall boundary conditions
- Calculation of various electromagnetic quantities such as electric fields, magnetic fields, surface currents, power flows, current densities, power loss densities, electric energy densities, magnetic energy densities, voltages or currents in time and frequency domain
- Calculation of time averaged power loss volume monitors
- Calculation of time averaged surface losses
- Discrete edge and face elements (lumped resistors) as ports
- Ideal voltage and current sources
- Discrete edge and face R, L, C, and (nonlinear) diode elements at any location in the structure
- Automatic parameter studies using built-in parameter sweep tool
- Automatic structure optimization for arbitrary goals using built-in optimizer
- Network distributed computing for remote computations
- Support for Transient Co-Simulation with CST Design Studio™
- Coupled simulations with the Thermal Solver from CST Studio Suite

Wakefield Simulator

- Particle beam excitation for ultra-relativistic and non-relativistic beams
- Transmission line injection scheme (improved dispersion characteristics)
- Arbitrary particle beam shapes for ultra-relativistic beams
- Automatic wake-potential calculation
- Automatic wake-impedance, loss and kick factor calculation
- Wakefield postprocessor allows to recompute wake impedances
- Mesh settings for particle beams
- Direct and two indirect wake-integration methods available
- MPI Cluster parallelization via domain decomposition
- Support of Linux batch mode
- Efficient calculation for loss-free and lossy structures
- Calculation of field distributions as a function of time or at multiple selected frequencies from one simulation run
- Adaptive mesh refinement in 3D
- Isotropic and anisotropic material properties
- Frequency dependent material properties
- Gyrotropic materials (magnetized ferrites)
- Surface impedance model for good conductors
- Port mode calculation by a 2D eigenmode solver in the frequency domain
- Automatic waveguide port mesh adaptation
- Multipin ports for TEM mode ports with multiple conductors
- High performance absorbing boundary conditions also for charged particle beams
- Conducting wall boundary conditions

- Calculation of various electromagnetic quantities such as electric fields, magnetic fields, surface currents, power flows, current densities, power loss densities, electric energy densities, magnetic energy densities, voltages or currents in time and frequency domain
- Calculation of time averaged power loss volume monitors
- Calculation of time averaged surface losses
- Discrete edge and face elements (lumped resistors) as ports
- Ideal voltage and current sources
- Discrete edge and face R, L, C, and (nonlinear) diode elements at any location in the structure
- Automatic parameter studies using built-in parameter sweep tool
- Automatic structure optimization for arbitrary goals using built-in optimizer
- Network distributed computing for optimizations, parameter sweeps and multiple port/mode excitations
- Support for Transient Co-Simulation with CST Design Studio™
- Coupled simulations with the Thermal Solver from CST Studio Suite

Eigenmode Simulator

- Calculation of modal field distributions in closed loss-free or lossy structures
- Support of hexahedral meshes as well as linear and curved tetrahedral meshes
- Isotropic and anisotropic materials
- Multithread parallelization
- Adaptive mesh refinement in 3D using eigenmode frequencies as stop criteria, with True Geometry Adaptation
- Periodic boundary conditions including phase shift
- Calculation of losses and internal / external Q-factors for each mode (directly or using perturbation method)
- Discrete L,C elements at any location in the structure
- Target frequency can be set (calculation within the frequency interval)
- Calculation of all eigenmodes in a given frequency interval
- Sensitivity analysis with respect to materials and geometric deformations defined by face constraints (with tetrahedral mesh)
- Automatic Lorentz force calculation
- Introduction of a General (Lossy) solver
- Support of Open Boundary conditions for accurate internal / external Q-factors calculation
- Support Tetrahedral mesh only with automatic Adaptive mesh refinement
- Automatic parameter studies using built-in parameter sweep tool
- Automatic structure optimization for arbitrary goals using built-in optimizer
- Network distributed computing for optimizations and parameter sweeps
- Coupled simulations with the Thermal Solver from CST Studio Suite

Electrostatics Simulator

- Isotropic and (coordinate-dependent) anisotropic material properties

- Sources: potentials, charges on conductors (floating potentials), uniform volume- and surface-charge densities
- Force calculation
- Capacitance calculation
- Electric / magnetic / tangential / normal / open / fixed-potential boundary conditions
- Periodic boundary conditions for hexahedral meshes
- Perfect conducting sheets and wires
- Discrete edge capacitive elements at any location in the structure
- Adaptive mesh refinement in 3D
- Automatic parameter studies using built-in parameter sweep tool
- Automatic structure optimization for arbitrary goals using built-in optimizer
- Network distributed computing for optimizations, parameter sweeps and remote calculations
- Coupled simulations with the Mechanical Solver from CST Studio Suite

Magnetostatics Simulator

- Isotropic and (coordinate-dependent) anisotropic material properties
- Nonlinear material properties
- Laminated material properties
- Sources: coils, permanent magnets, current paths, external fields, stationary current fields
- Discrete edge inductances at any location in the structure
- Force calculation
- Inductance calculation
- Flux linkages
- Electric / magnetic / tangential / normal / open boundary conditions
- Adaptive mesh refinement in 3D
- Automatic parameter studies using built-in parameter sweep tool
- Automatic structure optimization for arbitrary goals using built-in optimizer
- Network distributed computing for optimizations, parameter sweeps and remote calculations
- Coupled simulations with the Mechanical Solver from CST Studio Suite

Visualization and Secondary Result Calculation

- Multiple 1D result view support
- Import and visualization of external xy-data
- Copy / Paste of xy-datasets
- Fast access to parametric data by interactive tuning sliders
- Automatic parametric 1D result storage
- Displays port modes (with propagation constant, impedance, etc.)
- Various field visualization options in 2D and 3D for electric fields, magnetic fields, power flows, surface currents, etc.
- Animation of field distributions
- Particle and secondary electrons vs. time 1D plots (PIC)
- Collision event monitors for Monte-Carlo collisions

- Current/Power 1D plot of emitted and absorbed particles (PIC)
- Wave-Particle Power Transfer (PIC)
- Animation of 2D and 3D particle positions / momenta (PIC)
- Visualization of 3D particle trajectories (Tracking)
- Combined Visualization of 2D/3D fields and particle positions (PIC)
- Visualization of thermal loss distribution due to particle collisions with solids
- Display of source definitions in 3D
- Display of nonlinear material curves in xy-plots
- Display of material distributions for materials with nonlinear permeability
- Animation of field distributions
- Display and integration of 2D and 3D fields along arbitrary curves
- Integration of 3D fields across arbitrary faces
- Hierarchical result templates for automated extraction and visualization of arbitrary results from various simulation runs. These data can also be used for the definition of optimization goals.

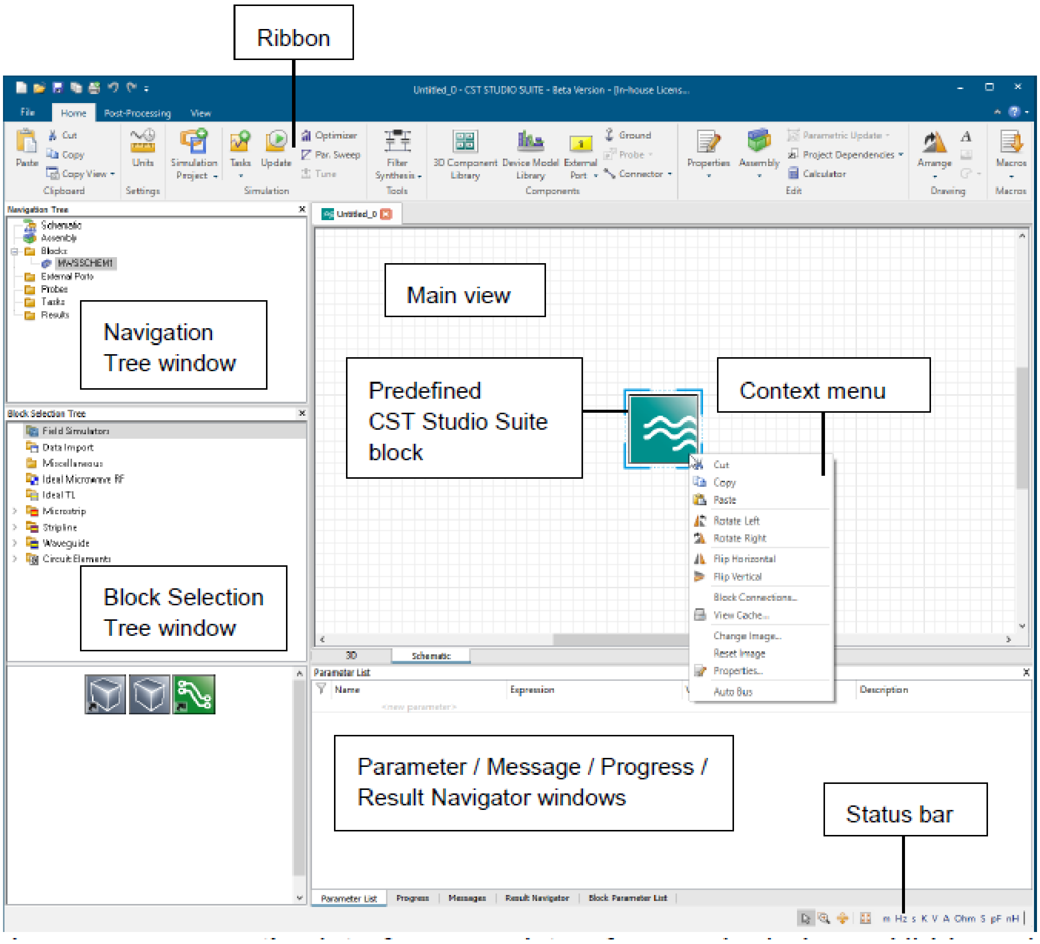
Result Export

- Export of result data such as fields, curves, etc. as ASCII files
- Export of particle data as ASCII files
- Export screen shots of result field plots

Automation

- Powerful VBA (Visual Basic for Applications) compatible macro language including editor and macro debugger
- OLE automation for seamless integration into the Windows environment (Microsoft Office®, MATLAB®, AutoCAD®, MathCAD®, Windows Scripting Host, etc.)

CST Design Studio Key Features



User Interface

- Intuitive and easy-to-use schematic view, for quick setup and definition of assemblies or circuits.
- Fast assembly viewer, showing and positioning the assembled components in full 3D.

Components / Circuit Models

- Several analytical components.
- Comprehensive analytical and 2D EM based microstrip and stripline component libraries.
- Active, passive, linear and non-linear circuit elements.
- Support of hierarchical modeling, i.e. separation of a system into logical parts.
- Tight integration with 3D EM field simulation of CST Studio Suite.
- Import of net lists and semiconductor device models in Berkeley SPICE, Cadence® PSpice® or Synopsis® HSPICE®1 format.
- Support of the IBIS data file format.
- FEST3D blocks for highly efficient wave guide distribution network modeling.

- Import of measured or simulated data in the TOUCHSTONE file format.
- Control and use of extensible element library.

SAM (System Assembly and Modeling)

- 3D representations for individual components.
- Automatic project creation by assembling the schematic's elements into a full 3D representation.
- Fast parametric modeling front end for easy component transformation and alignment.
- Manage project variations derived from one common 3D geometry setup.
- Coupled multiphysics simulations by using different combinations of coupled Circuit/EM/Thermal/Stress projects.
- Hybrid Solver Task (uni- or bi-directional coupling of 3D high frequency solvers).
- Antenna Array Task.
- Electrical Machine Task that performs and analyses various drive scenarios.

Analysis

- Global parameterization.
- Flexible and powerful hierarchical task concept offering nested sequence/parameter sweep/optimizer setups.
- Parameter sweep task with an arbitrary number of parameters.
- Optimization task for an arbitrary number of parameters and a combination of weighted goals.
- Template-based post-processing for user defined result processing.
- Tuning parameters by moving sliders and immediately updating the results.
- Powerful circuit simulator, offering DC, AC, S-Parameter, Transient and Harmonic Balance simulations.
- Interference Task to estimate possible interference violations on platforms carrying multiple sender and receiver modules.
- Robust and accurate handling of frequency domain data (e.g. S-Parameters) in time domain, including IDEM macro modeling capabilities.
- Net list file export in HSPICE format.
- Result cache for S-Parameters from high frequency simulation projects.
- Recombination of fields in CST Studio Suite for stimulations calculated in CST Design Studio.
- Fast time domain simulation of coupled problems by transient EM/circuit co-simulation.
- Automatic solver choice that automatically selects either an analytic or numerical evaluation of microstrip and stripline components depending on the validity of the analytic models.
- Consideration of higher order modes for wave guide port definitions.

Synthesis

- Filter Designer 2D for automatic design of lumped or 2D filter structures. All distributed filter structures have a 3D representation, ready for verification with full 3D EM field simulation.

- Filter Designer 3D synthesizes / optimizes band pass filter structures of arbitrary topology. SAM technology is used to automatically assemble the final 3D filter design by using predefined resonator / coupler elements from the component library.
- FEST3D synthesizes Low-Pass, Band-Pass and Dual-Mode wave guide filters, as well as wave guide Impedance Transformers.

Visualization

- Multiple 1D result view support.
- Automatic parametric 1D result storage.
- 1D/2D Eye diagram plots.
- Displays S-Parameters in xy-plots (linear or logarithmic scale).
- Displays S-Parameters in Smith charts and polar charts.
- Fast access to parametric data via interactive tuning sliders.
- Measurement functionality inside the views (axis markers, curve markers).
- Possibility of keeping and comparing results in user-defined result folders.

Result Export

- Export of S-Parameter data as TOUCHSTONE files.
- SPICE macro model export, representing Vector Fitting model results.
- Export of result data, e.g. 1D plots, as ASCII files.

Documentation

- Creation and insertion of text boxes and images inside the drawing for documentation purposes.
- Annotations inside the data views.

Automation

- Powerful VBA (Visual Basic for Applications) compatible macro language including editor and macro debugger.
- OLE automation for seamless integration into the Windows environment (Microsoft Office®, MATLAB®, AutoCAD®, MathCAD®, Windows Scripting Host, etc.).