CST MICROWAVE STUDIO®
Technical Specification

Key Features for High Frequency Simulation

The following list gives you an overview of the main features of CST Studio Suite for High Frequency Simulations. Note that not all of these features may be available to you because of license restrictions. Please contact a sales office for more information.

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, National Instruments 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
- 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 Solver from CST Studio Suite

- 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
- ☐ Coupled simulations with the Thermal Solver from CST Studio Suite
- ☐ 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 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
- Coupled simulations with the Thermal Solver and the Stress Solver from CST Studio Suite

- 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.
- ☐ 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)

- ☐ 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 and sinograms
- ☐ 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 / opened 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, with True Geometry Adaptation

- Open, conducting wall, and periodic boundary conditions including phase shift
- Accurate calculation of losses and internal / 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
- Coupled simulations with the Thermal Solver and the Stress Solver from CST Studio Suite
- Export of fields for corona discharge and multipactor analysis with Spark3D (tetrahedral mesh only)

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

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