

# CST MICROWAVE STUDIO®

## Technical Specification

1 April 2013

### Frontend Module

- For functionality and CAD/EDA import filter, see technical specifications of the CST STUDIO SUITE®

### Transient Solver Module

- Lossfree and lossy, isotropic and anisotropic material properties
- Conductor surface losses, skin effect
- Frequency dependent material properties with arbitrary order for permittivity and for permeability and material parameter fitting functionality
- Field-dependent microwave plasma and gyrotropic materials (magnetized ferrites)
- Surface impedance models (tabulated surface impedance, ohmic sheet, lossy metal, corrugated wall, material coating)
- Non-linear material models (Kerr, Raman)
- Temperature dependent materials with coupling to CST MPHYSICS STUDIO®
- Discrete edge or face R, L, C, and (nonlinear) diode elements at any location in the structure
- PERFECT BOUNDARY APPROXIMATION (PBA)® for accurate and fast computation of arbitrarily shaped objects.
- THIN SHEET TECHNIQUE (TST) (tm) special approach for the efficient computation of thin metallic objects, like housings...
- Automatic mesh generation (expert system) and adaptive mesh refinement using S-Parameter or OD results as stop criteria
- MULTILEVEL SUBGRIDDING SCHEME (MSS)(tm) conformal subgridding that supports PBA and TST.
- Boundary conditions: electric, magnetic, open(PML), conducting wall, periodic
- Excitation with port modes, discrete elements, discrete face ports, and plane waves (also circular and elliptical polarized)
- Port mode and impedance calculation by 2D-Eigenmode Solver, incl. Multipin-Ports
- Adaptive port meshing
- Inhomogeneous port accuracy enhancement for highly accurate S-parameter results, considering also low loss dielectrics
- Multi signal functionality for simultaneous or subsequent excitation of multiple ports
- Discrete edge or face elements (lumped resistors) as ports
- Ideal voltage and current sources for EMC problems
- Arbitrary time signal excitation
- Library functionality for excitation signals
- Excitation by current distributions from, CST PCB STUDIO®, CST CABLE STUDIO®, Simlab PCBMod, Simlab CableMod simulations.

- Excitation of external field sources imported from CST MICROWAVE STUDIO® or Sigrity®
- Broadband calculation of S-parameters
- Auto regressive (AR) filtering for fast time domain calculation of resonant structures
- Single-ended S-parameter calculation
- S-parameter symmetry option to decrease solve time for many structures
- Re-normalization of S-parameters for specified port impedances
- Phase de-embedding of S-parameters
- S-parameter sensitivity and yield analysis
- Monitoring of electromagnetic fields at arbitrary frequency points in one simulation run
- Shared memory parallelization of the transient solver run and the matrix calculator
- Time Domain and Frequency Domain monitoring of electromagnetic fields (E, H, J, energy, powerflow, farfield)
- Broadband calculation of antenna farfields, gain, directivity etc.
- Antenna array farfield calculation
- Radar cross section (RCS) calculation
- Specific absorption rate (SAR) calculation
- Time Domain Reflectometry (TDR) simulation
- Distributed Computing (2 ports)
- Multi-processor option; up to 48 cores on one board
- MPI Cluster parallelization via domain decomposition (option), with support for models with over 2 billion mesh cells.
- Support of GPU acceleration with up to eight acceleration cards (option)
- Combined simulation with MPI and GPU acceleration (option)
- Further distributed computing options available
- Support of Linux batch modus and batch queuing systems (e.g. OGE, LSF)
- Transient EM/circuit co-simulation with CST DESIGN STUDIO
- Transient radiation, irradiation or bi-directional co-simulation with CST CABLE STUDIO
- Coupled simulations with Thermal Solver from CST MPHYSICS STUDIO
- Co-simulation with AWR Microwave Office
- Parametric co-simulation with Agilent ADS
- Export of Touchstone® files

## 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 like radiated and conducted emissions and immunity, EMP and lightning, electrostatic discharge (ESD), high speed interference and shielding analysis

- Interface with CST CABLE STUDIO®
- Compact models which avoid for excessively fine meshes, for: slots, seams and gaskets, air-vents (square, round and honeycomb holes), multi-conductor wires, shielded cables, frequency-dependent thin panels, conductive coatings and absorbers
- Broadband compact antenna radiation sources based on the Equivalence Principle
- Broadband compact PCB sources for EMC analysis, with imports from CST PCB STUDIO® and Sigrity® tools
- 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
- Antenna farfield calculation (including gain, beam direction, etc.)
- Cylinder scan for emissions analysis yielding peak radiated fields vs. frequency
- Coupling into shielded cables for transient protection analysis
- 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
- Support of GPU acceleration (option)

## Frequency Domain Solver Module

- Choice of Cartesian, linear tetrahedral or curved tetrahedral meshing
- Direct and iterative solvers with convergence acceleration techniques
- Automatic fast broadband adaptive frequency sweep
- Extrapolation to DC (static)
- Low frequency stabilization
- Automatic mesh generation (expert system) and adaptive mesh refinement 3D using S-parameters at multiple frequency points or broadband S-parameters as well as 0D result templates as stop criteria
- First, second, third and mixed order field computation in tetrahedral mode
- True Geometry Adaptation for reliable convergence of simulation results
- MPI Cluster parallelization via domain decomposition for the direct solver (general purpose solver with tetrahedral mesh only)
- Support of Linux batch modus and batch queuing systems (e.g. OGE, LSF)
- Lossfree and lossy, isotropic and anisotropic material properties
- Arbitrary frequency dependent material properties
- Surface impedance model for good conductors, Ohmic sheets and corrugated walls, as well as frequency-dependent, tabulated surface impedance data (tetrahedral mesh only)
- Inhomogeneously biased Ferrites with a static biasing field (tetrahedral mesh only)
- Boundary conditions: electric, magnetic, open(PML), conducting wall, periodic with arbitrary phase shift or scan angle
- Special unit cell boundary conditions
- Floquet mode boundary conditions (ports)
- Excitation by waveguide ports (including slanted ports), discrete ports, plane wave
- Multipin ports for TEM mode ports with multiple conductors

- Port mode and impedance calculation by 2D-Eigenmode Solver
- Automatic waveguide port mesh adaptation (tetrahedral mesh only)
- Plane wave excitation with linear, circular or elliptical polarization (tetrahedral mesh only)
- Discrete edge and face elements (lumped resistors) as ports (face elements: tetrahedral mesh only)
- Lossy waveguide ports
- Lumped R, L, C elements at any location in the structure (general purpose solvers)
- Ideal current source for EMC problems (tetrahedral mesh only, restricted)
- Re-normalization of S-parameters for specified port impedances
- Phase de-embedding of S-parameters
- Single-ended S-parameter calculation
- S-parameter sensitivity and yield analysis (general purpose solver with tetrahedral mesh only)
- Monitoring of electromagnetic fields (E, H, J, energy, powerflow, farfield)
- Antenna farfield calculation (including gain, beam direction, side lobe suppression, etc.) with and without farfield approximation
- Antenna array farfield calculation
- Fast farfield and RCS calculation based on the Floquet port aperture fields (tetrahedral mesh only)
- RCS calculation (tetrahedral mesh only)
- Calculation of SAR distributions (hexahedral mesh only)
- Export of field source monitors, which then may be used to excite the transient simulation (tetrahedral mesh only)
- Export of fields for corona discharge and multipactor analysis with Fest3D (general purpose solver with tetrahedral mesh only)
- Automatic parameter studies using built-in parameter sweep tool
- Automatic structure optimization for arbitrary goals using built-in optimizer
- Multi-processor option; up to 48 cores on one board
- Distributed Computing (2 Frequency points)
- Further distributed computing options available
- Coupled simulations with Thermal Solver and Stress Solver from CST MPHYSICS STUDIO®
- Co-simulation with AWR Microwave Office
- Parametric co-simulation with Agilent ADS
- Besides the general purpose solver, the frequency domain solver also contains two solvers specifically designed for highly resonant structures, allowing calculation of S-parameters only (hexahedral mesh) or fields and S-parameters (hexahedral and tetrahedral meshes).

## Eigenmode Solver Module

- Calculation of modal field distributions in closed loss free or lossy structures
- Isotropic and anisotropic materials
- Hexahedral mesh with PERFECT BOUNDARY APPROXIMATION (PBA)® for accurate and fast computation of arbitrarily shaped objects.

- Support of linear and curved tetrahedral meshes
- Automatic mesh generation (expert system) and adaptive mesh refinement
- Adaptive mesh refinement in 3D using eigenmode frequencies as stop criteria, with True Geometry Adaptation for tetrahedral meshes.
- Frequency target can be set (calculation in the middle of the spectrum)
- Calculation of all eigenmodes in a given frequency interval
- Frequency target can be set (non-extremal eigenmodes)
- Calculation of all eigenmodes in a given frequency interval
- Periodic boundary conditions with arbitrary phase shift
- Lumped elements (L and C)
- Calculation of losses and internal / external Q-factors for each mode (directly or using perturbation method)
- Automatic parameter studies using built-in parameter sweep tool
- Automatic structure optimization for arbitrary goals using built-in optimizer
- Multithread parallelization
- Network distributed computing for optimizations and parameter sweeps (option)

## Integral Equation Solver Module

- Integral Equation solver based on the method of moments (MoM) and the Multilevel Fast Multipole Method (MLFMM)
- Direct and iterative matrix solvers with convergence acceleration techniques
- Higher order representation of fields including mixed order
- Automatic fast broadband adaptive frequency sweep
- Low frequency stabilization
- Surface mesh discretization
- Wire mesh discretization
- Single and double precision floating-point representation
- Lossy dielectric materials, lossy metal, ohmic sheets with complex impedance.
- Coated materials
- Arbitrary frequency dependent material properties
- Isotropic material properties
- Infinite electric and magnetic ground planes
- Handling of curved layered media
- Excitation with waveguide ports (including lossy ports)
- Port mode calculation by a 2D eigenmode solver in the frequency domain
- Plane wave excitation (also circular and elliptical polarized)
- Farfield excitation
- Farfield excitation with multipole coefficient calculation
- Receiving farfield excitation

- Current distribution
- Excitation with discrete edge ports
- Excitation with discrete face ports
- Re-normalization of S-parameters for specified port impedances
- Phase de-embedding of S-parameters
- RCS calculation
- Fast monostatic RCS sweep
- Calculation of various electromagnetic quantities such as electric fields, magnetic fields, surface currents
- Antenna farfield calculation (including gain, beam direction, side lobe suppression, etc.)
- MPI parallelization for MLFMM and direct solver
- Support of Linux batch modus and batch queuing systems (e.g. OGE, LSF)
- Multithread parallelization
- Network distributed computing for optimizations and parameter sweeps (option)
- Network distributed computing for frequency sweeps (option)

## Multilayer Solver

- Calculation of S-parameters and surface currents
- Waveguide (multipin) port excitation
- Discrete face port excitation
- Efficient calculation of loss-free and lossy structures
- Surface mesh discretization
- Automatic edge mesh refinement 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
- Multithread parallelization
- MPI parallelization for the direct solver
- Network distributed computing for optimizations and parameter sweeps (option)
- Network distributed computing for frequency sweeps (option)

## Asymptotic Solver Module

- Specialized tool for fast monostatic and bistatic farfield and RCS sweeps
- Multiple plane wave excitations with different polarization types

- Farfield source excitations
- PEC and vacuum material properties
- Robust surface mesh discretization
- User defined frequency sweeps and angular sweeps
- Fast ray tracing technique including multiple reflections and edge diffraction (SBR) by using either independent rays or ray-tubes
- Complex surface impedance materials
- Coated materials
- Automatic parameter studies using built-in parameter sweep tool
- Automatic structure optimization for arbitrary goals using built-in optimizer
- Visualization of rays including multiple reflections
- Computation of range profiles and sinograms
- Multithread parallelization
- Network distributed computing for optimizations and parameter sweeps (option)
- Network distributed computing for excitation angles (option)

## Automation

- Fully parametric 3D modelling
- VBA macro language
- OLE automation server
- Automatic parameter studies using built-in parameter sweep tool
- Template based postprocessing
- Automatic structure optimization for arbitrary goals using built-in optimizer

## CST Simulation Acceleration

- Acceleration options handled by a token scheme

## Documentation

- See technical specifications of the CST STUDIO SUITE

## Minimum Hardware Requirements

- Intel® Xeon® based PC, 4GB RAM, DVD-Drive, at least 20 GB of free hard disc space.
- Fully OpenGL compliant graphics card
- Windows XP Professional, Windows Vista, Windows 7
- All solvers (except TLM and Multilayer) support RedHat Enterprise Linux (RHEL) 4.x und 5.x.
- Hardware recommendation depends on your application. If in doubt, please contact your local sales office for further information.

## General

- CST MICROWAVE STUDIO® is a configurable tool with a choice of several solver modules. Not all listed options are included in the standard license. Not all listed features are available with all solvers. The standard configuration is one full solver process with one solver module and one additional frontend. Floating and node-locked licenses are available. Please contact your local sales office for further information.