

High-speed Matrix Solver Library

Super Matrix Solver

**Super Matrix Solver
FAQ**

Rev. C



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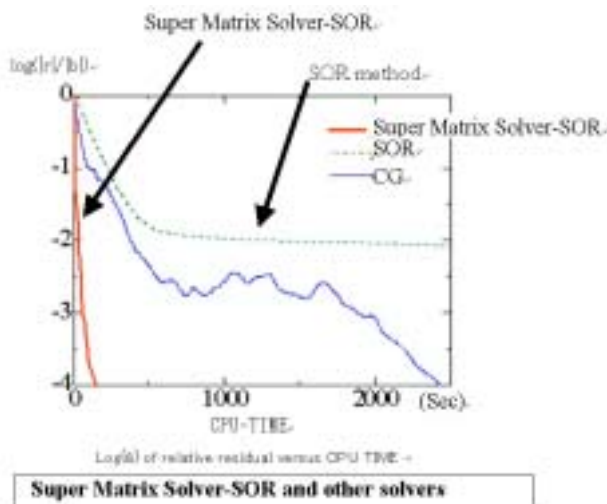
Super Matrix Solver FAQ

Q1: What is Super Matrix Solver?

The term “Super Matrix Solver” is used in two different ways. One is in which the technology itself is referred to, and the other is in which products (software library) is referred to.

1) Super Matrix Solver technology

Super Matrix Solver technology is developed by VINAS and is capable of accelerating and stabilizing solution process of iterative matrix solvers. It can be integrated into conventional iterative solver methods to make them faster and more robust.



See the figure on the left.

It shows comparison of Super Matrix Solver-SOR with conventional SOR method regarding their performances.

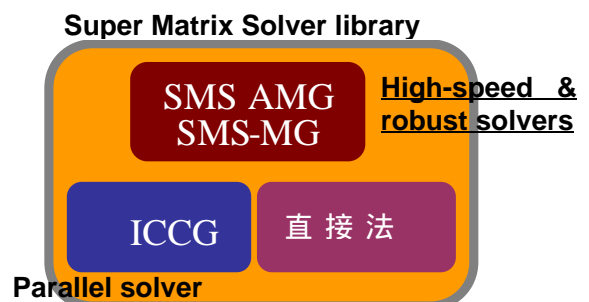
It is obvious from this that Super Matrix Solver-SOR is considerably faster and more robust than conventional SOR method.

2) Super Matrix Solver

Super Matrix Solver is a library of matrix solver products using various iterative solver algorithms.

There are two main groups of solvers: one is high-speed and robust solvers using Super Matrix Solver technology, and the others are parallel solvers and direct method solvers.

Users can choose which solvers to purchase according to the size of their problems and according to required performances.



Q 2: Can Super Matrix Solver be used for solvers other than CFD solvers?

Solver modules included in Super Matrix Solver library can be used by wide range of solvers which are used for solving simultaneous linear equations derived from discretization of partial differential equations.

Super Matrix Solver's field of application

- CFD solvers FEM analysis solvers
- Mold flow analysis solvers Electromagnetic analysis solvers
- Solvers of optimum control problems
- Other solvers which are used for solving simultaneous linear equations.

Q 3: We are developing an FEM solver. Can we use Super Matrix Solver Library?

Super Matrix Solver library is a general use matrix solver. Therefore, it can be used for any FEM solver if the application discretizes analysis problems into the form of $AX=b$ (See also Q.2).

Other required conditions are that the matrix is a sparse matrix and that all diagonal elements have non-zero values.

Q 4: We are using a commercial CAE solver. Can we integrate Super Matrix Solver into the commercial CAE solver that we are using?

It is basically possible to integrate Super Matrix Solver into solvers that solve simultaneous linear equations. Many commercial CAE solver package developers, however, do not disclose the source code of the solver or provide interfaces to external matrix solvers. In such cases, please consult us for possible integration of Super Matrix Solver into the CAE solver.

Q 5: Can Super Matrix Solver solve matrices generated from low quality mesh?

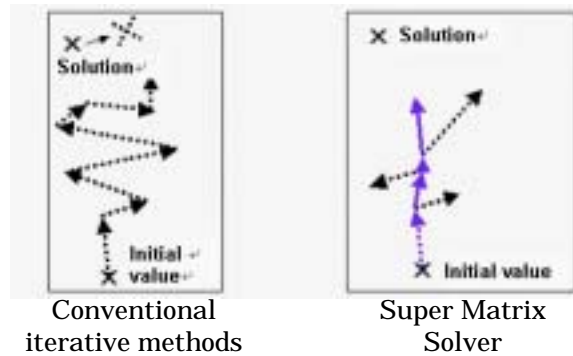
It has been shown through testing that solver modules using Super Matrix Solver are very robust and can solve many difficult linear equations that can not be solved by other matrix solvers using conventional solution method.

Usually low quality meshes lead to difficulty for solvers to make the solution converged. We have found that Super Matrix Solver can quickly converge solutions to "stiff" matrices generated from meshes with aspect ratio of up to several hundreds.

Q 6: I heard that each iteration of Super Matrix Solver takes more time than each iteration of other iterative solution methods. Is it really so?

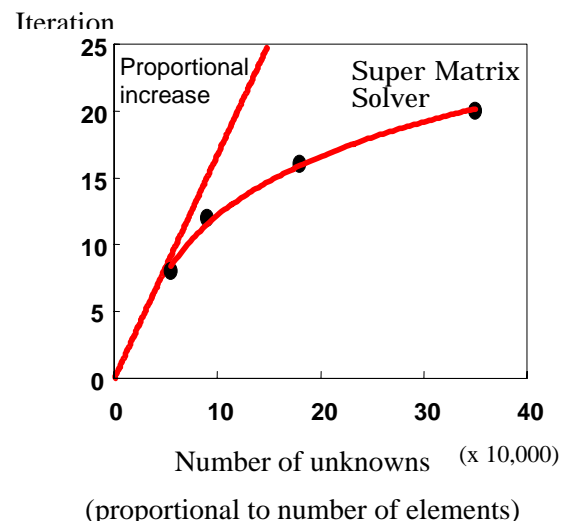
Super Matrix Solver has a unique feature of searching the best way of defining new iteration so that residual is minimized, and therefore each iteration takes a little more time than in conventional iterative methods. This unique feature makes it possible to achieve higher

■ Super Matrix Solver has an optimization algorithm to accelerate and stabilize solution process of iterative methods such as SOR and AMG.



convergence level per iteration, and the total number of iteration required for a certain level of convergence becomes much less. As a result, total time required for a certain level of convergence can be considerably reduced by Super Matrix Solver.

Another advantageous feature of Super Matrix Solver is that time required for calculation does not increase as much as in conventional methods when the number of unknowns, which is proportional to number of elements, is increased. Therefore, it is capable of obtaining converged solution without considerable increase in calculation time.



Q 7: Is it capable of solving asymmetric matrices?

Use of Super Matrix Solver is not limited to symmetric matrices. It can be used for solution of either symmetric or asymmetric matrices.

Q 8: Are there any limitations to the size of matrix to be solved by Super Matrix Solver?

Super Matrix Solver itself does not have limitations regarding the size of matrix to be solved. It has been shown through tests that Super Matrix Solver is capable of solving problems with up to 3 million unknowns with high speed and high stability. However, for large scale problems, size of computer memory must be considered, because Super Matrix Solvers use about ten percent more memory^(*1) than conventional solution methods that they are base on, in order to accelerate and stabilize the base solution method .

When the size of memory is not big enough on a particular computer system, virtual memory such as hard disk is used, but in such cases processing time considerably increases. It is recommended that the size of memory be checked before starting calculation so that the computer can handle the problem to be solved.

*1) It is possible that more than ten percent extra memory is needed depending on characteristics of problems.

Q 9: What is necessary to integrate Super Matrix Solver into my solver?

Solver modules consisting Super Matrix Solver library are provided as DLLs so that they can be integrated into analysis solvers. Integration of solver modules of Super Matrix Solver can be made by calling them using programming languages such as Fortran and C, which can call external functions.

So far we have verified proper operation of Super Matrix Solver with Compaq Visual Fortran® Version 6.1, 6.5 for Fortran base source codes, and Microsoft ® Visual C++® 6.0 and others for C base source codes.

Q 10: Can a problem based on structured grid be solved? What about unstructured?

Type of matrix data will be different according to type of grid (structured or unstructured) used for discretization. Based on the type of used, a suitable solver module can be selected from Super Matrix Solver library. See the table below to find out which solver module is available for which type of problem.

Solver module	Structured grid type data	Unstructured grid type data
Super Matrix Solver-MG	○	
Super Matrix Solver-AMG	○	○

(“○” means that calculation of that data type is supported)

Q 11: Is it possible to solve a matrix containing a diagonal element of which value is zero?

Basically, SMS-AMG can not solve problems that include diagonal elements whose values are zero. However, problems with zero diagonal elements as a result of multiple degrees of freedom might be solved by SMS-AMG V2. SMS-AMG V2 handles zero diagonal elements of multiple degrees of freedom problems by internally dividing the problems.

For the problems that can not be solved by SMS-AMG V2, there is a possibility that our P-ICCG solver may be useful. Please consult with us for specific cases.

Q 12 : Is it possible to solve a dense matrix?

There is a possibility that a dense matrix can be solved by our direct method solvers. We are currently developing a direct method solver dedicated to solution of equation systems (FULL MATRIX) derived from BEM (boundary element method) method. The BEM solver can be flexibly adjusted to specific problems. Consult with us about customized tuning of the BEM solver to your problems.

Q 13: Do I need to know a lot about mathematics to use Super Matrix Solver library?

Special knowledge of mathematics is not necessarily required for using Super Matrix Solver library because its solvers are provided as completed modules (library files). These modules can be integrated into your application by following instructions provided in User's manual.

Q 14: Is UNIX supported?

Currently, Windows® versions, SGI® IRIX® versions, some UNIX® versions and LIUNIX ® (32bit, 64bit) versions are available. Other UNIX® versions are planned, but not yet ready. If you have a specific need for UNIX® version of Super Matrix Solver, please let us know.

Q 15: Is concurrent use by different machines supported? Is it possible to use the executable copied to different machines?

Modules of Super Matrix Solver control user license by referring to physical address specific to each machine. Therefore, solver modules do not run on machines other than the one to which license password is issued. During development phase, integration of modules of Super Matrix Solver can be carried out without license password. If a machine other than the one used for development phase is to be used for calculation, license password for that machine must be obtained. If more than one machines are to be used, password for each machine is needed.

Q 16: Are there parallel versions of solver modules?

Currently, SMS-AMG is not available in parallel implementation. However, there is a strong demand in parallel versions, and we consider development of parallel versions as one of our priorities. Super Matrix Solver technology is by nature suited for parallel implementation, and a high performance enhancement is expected once parallel implementation is introduced.

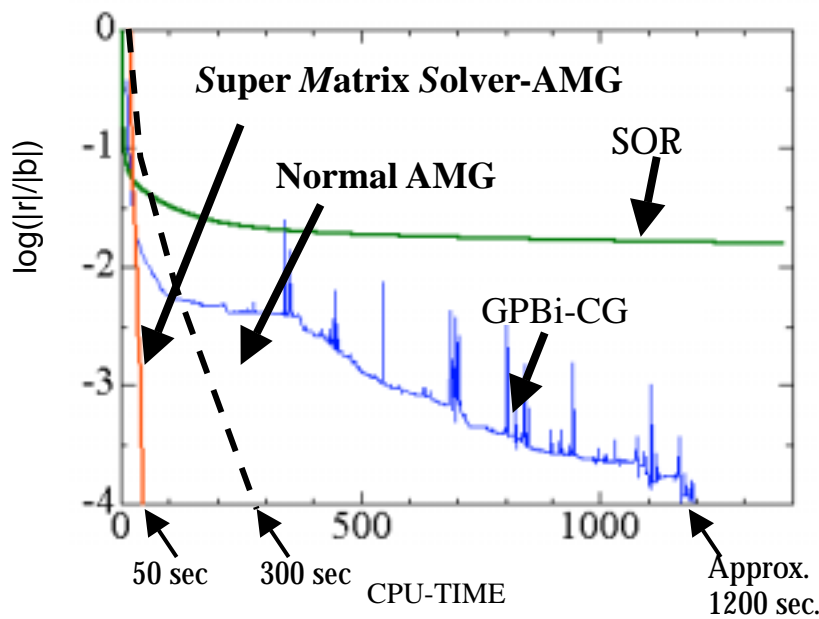
However, parallel version of ICCG solver is now available. It is called P-ICCG and it supports SMP parallel implementation. You can easily parallelize an equation system problem for calculation by from 2 to 8 CUP Windows platform.

Q 17: Is it possible to apply Super Matrix Solver technology to CG type methods?

Conjugate gradient method (CG method) can be classified as one type of vector iterative solution methods, and it uses similar mathematical process as Super Matrix Solver. Applying Super Matrix Solver to CG method means applying two similar processes, and the advantages of Super Matrix Solver, which is to make solution process faster and more robust do not work as much as for other solution methods. Therefore, we are planning to include CG method solver in the library as a conventional solver without application of Super Matrix Solver technology.

Q 18: What is the difference between Super Matrix Solver-AMG and normal AMG method?

AMG (Algebraic Multi Grid) method is a new iterative solution method developed in 1980s to 1990s. It is a very fast solution method, but it is not widely used because of difficulties in programming of the method and parameter setting. Super Matrix Solver-AMG is a matrix solver developed by VINAS by applying Super Matrix Solver technology to AMG method. As you can see in the figure below.



Calculation of 1.1 million unknowns

Logarithm of relative residual vs CPU time for calculation

* GPBi-CG is relatively fast and robust among CG

Super Matrix Solver-AMG and other solver methods

Q 19: Is it possible to apply Super Matrix Solver to solvers using explicit methods?

Super Matrix Solver can not be applied to explicit methods, because Super Matrix Solver solves simultaneous linear equation systems but explicit solvers do not. However, some solvers use both explicit method and implicit method, and in that case Super Matrix Solver can be applied to process of solving simultaneous linear equation system. Super Matrix Solver can be applied to matrix solution processes using direct method or iterative method.

Q 20: Will the performance depend on integration method with application?

Product modules of Super Matrix Solver are optimized for the maximum performance, and its performance will not depend on integration method with your application (such as using DLL and so on). Effect of integration method is almost negligible, and users do not need to touch the source code for performance improvement.

Q 21: Is SMS capable of calculating eigenvalue or inverse matrix?

Super Matrix Solver can be used only for calculating unknown vector x in simultaneous linear equation system $Ax=b$. Therefore, it is not capable of calculating eigenvalue of matrix or inverse matrix.

Q 22: Is it possible to check the performance of SMS before purchasing a license?

There are two ways in which you can check the performance of SMS for your application.

1. Checking the performance of SMS in solving your matrix

Provide us with your matrix data. We will run Super Matrix Solver to solve the matrix. After we finish solving your matrix, we will send you a report detailing the result (including convergence history plot, time needed for solution, use of memory, etc.).

[Advantages of this checking] It can be done quickly. You do not have to spend time on integration of SMS into your application. You can check how much reduction of time in solving matrix be expected.

2. Checking of performance of SMS by integrating it with your application

We will provide you with an evaluation license of Super Matrix Solver so that you can integrate the code with your application.

[Advantage of this checking] You can check the total time saved by using SMS on the level of your application.

We have a document explaining the format of matrix that you can send us for testing and the steps involved in benchmark tests.

Q 23: Can SMS solve problems with multiple degrees of freedom?

SMS-AMG V2 (coupled method) is capable of handling problems that have multiple types of unknowns (x, y, z displacements, u, v, w velocities, etc.) in an equation system. This is one of the major difference from the SMS-AMG V1 (segregated method), which is capable of solving problems with only one degree of freedom.

Q 24: Can SMS solve electromagnetic problems with edge elements?

SMS-AMG V2 has been successful in calculating 2D edge elements, but it does not handle 3D edge elements. We are planning to develop a new version that can handle 3D edge elements in the year 2005. For edge elements, P-ICCG (Parallel ICCG supporting SMP) is currently available.

Q 25: Can SMS be used for structural analysis?

SMS-AMG V2 supports calculation of models with solid elements, in which a node has 3 degrees of freedom. However, it does not support models with shell, beam, sliding or rigid body elements, in which a node has 6 DOF. In order to calculate models with 6 DOF, you need V3, which is planned to be developed in the future.