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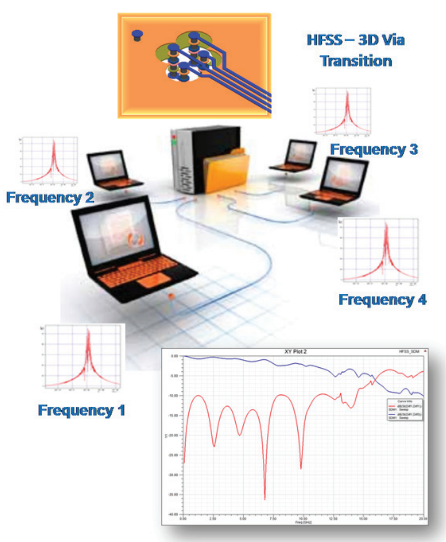
White Paper

ANSYS HFSS High-Performance Computing Capabilities to Help Deliver Better Products Faster

Manufacturers of electronics products strive to develop products with greater functionality, higher levels of performance and improved robustness — and to bring them to market in less time. With simulation driving the design process at many companies, this means solving more iterations of larger models with more complex physics than ever before. The time required to simulate models can become a significant bottleneck in the product development cycle. ANSYS has addressed this challenge by substantially improving the high-performance computing (HPC) capabilities of ANSYS® HFSS™, the industry-standard simulation tool for 3-D full-wave electromagnetic field simulation. HPC-enabled multithreading (HPC-MT) in HFSS provides solutions five times faster than on a single core and 20 percent faster than the previous-generation multiprocessing (MP) solver. HFSS also provides an HPC-enabled spectral decomposition method (SDM) that accelerates frequency sweeps through parallel frequency point extraction. In some examples, SDM has provided a 16.6-times speedup when implemented on a 32-compute-engine cluster. Finally, implementation of a message-passing interface (MPI) has accelerated HFSS domain decomposition solutions. This allows users to further leverage networked compute resources to solve bigger problems; it often provides additional simulation speed improvements.



The spectral decomposition method in ANSYS HFSS-HPC accelerates frequency sweeps by distributing the spectral content across a network of processors.

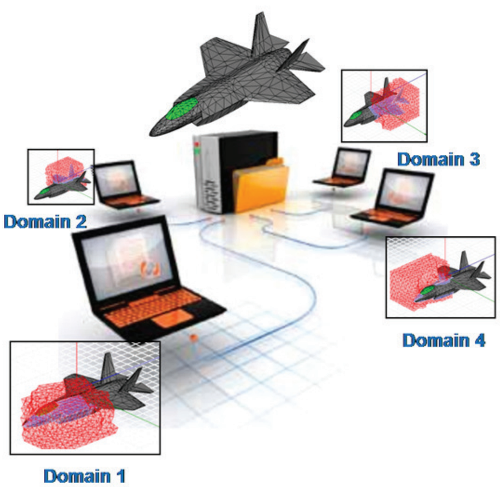
Electronic Design Challenges

Engineers designing electronic products — such as cell phones, tablet computers, software-defined radios, microwave circuits and components, active antennas, and more — continually push the limits of simulation to solve ever-larger and more complex electromagnetic and signal integrity problems. Engineers need to determine system-level performance and interaction among the various components and subsystems before expensive prototypes are produced and tested in the integration lab.

Modern electromagnetic simulation must be able to handle 3-D systems that are physically complex, have a large range of physical dimensions, and are assembled with models from disparate sources that can include multiple 3-D computer-aided design (CAD) and 2-D layout design tools. It is often impossible for one single electromagnetic simulation technique to solve the entire system to the desired level of accuracy, making it necessary to apply the appropriate solver technology to particular areas of the system.

The HPC option substantially reduces solution times, enabling designers to evaluate more design iterations early in the design process to optimize the design and deliver higher product performance. As a result, an engineering team gains:

- Increased productivity
- Higher-fidelity simulation
- Capability to solve larger problems



The domain decomposition method included in HPC enables ANSYS HFSS to solve extremely large models by automatically creating mesh subdomains and distributing them to a network of processors.

Improved HPC Capabilities

The latest release of ANSYS HFSS contains a number of dramatic HPC improvements that more efficiently harness multicore and networked processing power to address these challenges. The HFSS HPC option substantially reduces solution times, enabling designers to evaluate more design iterations early in the design process to optimize the design and deliver higher product performance. HPC also enables larger simulations that help in understanding system-level performance and determining the interactions between subsystems. HPC makes it possible to perform higher-fidelity simulations that deliver more accurate results with faster turnaround on larger models. The addition of HPC can make your engineering staff and your product development process more productive and efficient. By conducting larger, more detailed and accurate simulations, engineers can study entire systems as well as the interaction between components, thereby gaining greater confidence that their work will predict the actual performance of real-world products. Considering more design ideas and running simulations at a higher level of fidelity translates into a long-term competitive advantage.

Performing Simulations Faster

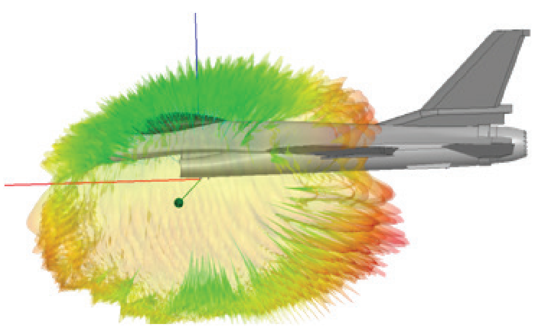
Using multithreading technology, HFSS takes advantage of multiple cores on a single computer to reduce solution time. Available with HFSS, HFSS-IE (integral equation) and HFSS-Transient, the multithreading technology speeds up the initial mesh generation, direct and iterative matrix solves, and field recovery. This provides up to 20 percent better performance than the previous-generation MP solver. Performance is for one particular example by 1.9X with two cores, 3.6X with four cores and 5.6X with eight cores.

The majority of electromagnetic simulations require results such as field, far-field and s-parameter data over a range of frequencies. The traditional method, consisting of running each frequency in sequence, is often time consuming. The spectral decomposition method (SDM) technology in HFSS distributes multiple frequency solution over networked compute cores to accelerate frequency sweeps. SDM is scalable to large numbers of cores, offering speedup on a typical example of 5.3X with eight SDM points on eight cores and 16.6X with 32 SDM points on 32 cores. SDM and multithreading may be used in tandem to speed up the extraction of each individual frequency point and perform many frequency points in parallel.

HFSS-Transient distributed parallel (HPC-DP) accelerates HFSS-Transient solutions by distributing the solution of multiple excitations across networked processors. HPC-DP also combines synergistically with multithreading to further increase solution speed for transient.

With faster simulation, your engineering staff and product development processes can become more productive and efficient. HPC delivers faster turnaround:

- Up to five times solver speeds
- 20 percent faster than multiprocessing



Using HPC with the ANSYS HFSS-IE solver is ideal for calculating antenna performance of large conducting structures. Simulation capacity and speed is significantly increased by distributing the matrix solution to a network of processors.

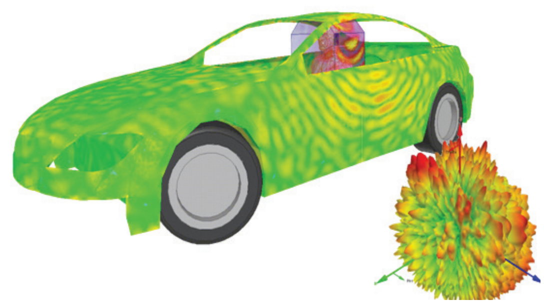
Solving Larger, More Complex Problems

The HFSS domain decomposition method (HPC-DDM), periodic domain decomposition method (HPC-pDDM), HFSS-IE distributed matrix (HPC-IE DM) and hybrid HFSS finite element method (FEM) with IE regions (HPC-hDDM) are new solver technologies introduced in recent releases of HFSS that distribute the simulation across multiple, potentially networked cores to solve larger and more complex problems. These methods are primarily designed to tackle larger problems, and the distributed nature of the solution provides results in shorter solution times.

HPC-DDM generates a continuous finite element mesh over the entire structure, then subdivides that mesh and uses a distributed memory parallel technique to distribute the solution for each mesh subdomain to a network of processors to substantially increase simulation capacity. HPC-DDM is highly scalable to large numbers of processors and takes advantage of multithreading within the mesh subdomains to reduce solution times for individual subdomains. This method automatically generates balanced subdomains using mesh partitioning and implements a direct matrix solver for each. Subdomains exchange information across a Robin's transmission condition iteratively using an industry-standard MPI.

HPC-pDDM uses a distributed memory parallel technique for finite periodic geometries such as antenna arrays. This method distributes unit cell mesh subdomains to a network of processors and RAM while an industry-standard MPI maintains communications between the domains. Simulation capacity and speed is substantially increased by re-using the adaptive mesh from a single unit cell for a large finite periodic structure and by processing the duplicated unit cells across a large number of processors. This method combines with multithreading to provide faster solves for each of the individual subdomains. The automated generation of domains makes this method easy to learn and implement.

HPC-IE DM provides a distributed memory parallel technique for the HFSS integral equation (HFSS-IE) solver. HFSS-IE is an optional, add-on solver that uses the method of moments (MoM) technique to solve for the sources and currents on the surfaces of conducting and dielectric objects. HFSS-IE is an effective add-on tool for radiation and scattering studies of large, mostly conducting structures. HPC-IE DM significantly increases HFSS-IE simulation capacity by using the distributed memory parallel technique to distribute the matrix solution to a network of processors and RAM. This method combines with multithreading to provide faster solves for each of the individual subdomains.



HPC increases capacity and solution speed of simulations best solved with HFSS hybrid solution methodology (mixed FEA and IE simulations).

HPC's increased capacity offers a number of benefits:

- Solve larger simulations with new MPI-based domain solutions
- Connect compute resources for an unparalleled distributed RAM experience

HPC-hDDM uses the domain decomposition method on models consisting of finite element and IE domains. The IE solver add-on makes it possible to create HFSS models that use a hybrid FEM–IE methodology to solve large EM problems. The hybrid methodology provides the best of two powerful techniques: the finite element method's ability to handle complex geometries plus the MoM's direct calculation of the free-space Green's function, which leads to accurate radiating and scattering solutions. The HPC-hDDM method significantly increases simulation capacity by using the distributed memory parallel technique to distribute the matrix solution to a network of processors and RAM.

HFSS HPC Enables Design Optimization and Robust Design

The dramatic improvement in simulation speed provided by HFSS HPC opens the door to optimizing the design by mapping out the complete design space. Hence, users can confidently identify the design that not just meets specifications but provides the highest possible level of performance while meeting other constraints. ANSYS simulation tools operate in the ANSYS Workbench™ environment that makes design optimization a very simple extension of a single simulation. When you change a geometry parameter, ANSYS meshing tools are smart enough to re-apply the previous setup, including mesh distributions specific to the changed entities. ANSYS solvers can also re-apply their setup and solve the new model. The post-processor can then regenerate all of the images, tables, animations and reports, etc. This enables engineers to easily compare different designs.

ANSYS DesignXplorer® provides seamless data transfer between applications and a process controller that sequentially simulates all of the design points and collates the outputs. When the user clicks the *Update All Design Points* button, the first design point, with the first set of parameter values, is sent to the parameter manager in the Workbench integration platform. This drives the changes to the model from the CAD system to post-processing. The new design point is simulated, and output results are passed to the design point table where they are stored. The process continues until all design points are solved, defining the design space so that it can later be optimized.

In the real world, values of manufacturing as well as operational or environmental variables such as dimensions, loads, boundary conditions and material properties that are assumed to be fixed in simulation actually vary due to manufacturing tolerances and other factors. DesignXplorer includes six sigma analysis that uses information about the uncertainty of input parameters to determine the expected output variation. This helps to determine whether or not the design meets robustness requirements. If not, the user can look at the sensitivity plot and other charts to determine which parameters need to be adjusted or tightened to obtain the required robustness. This information can also reveal which tolerances can be relaxed without compromising the design.

The HFSS distributed solve option (DSO) accelerates sweeps of design variations by distributing the design iterations across a network of processors. It works synergistically with multithreading to increase the execution speed of each design iteration. HFSS DSO offers a near-linear speedup over conventional design sweeps and is scalable to large numbers of cores. For example, 32 variations can be solved on 32 cores in 1/32 of the time required on a single core. DSO is available with HFSS, ANSYS Designer®, ANSYS Q3D Extractor® and ANSYS Maxwell®; it integrates with DesignXplorer and requires ANSYS Optimetrics™ and a distributed solve license.

HFSS HPC Licensing Options

ANSYS offers a range of licensing options to help users meet current requirements and plan for seamless upgrades related to future needs. Each HPC license can be used with any ANSYS electronics product including HFSS, HFSS-IE, HFSS-Transient, Designer, Q3D Extractor, Maxwell and ANSYS SIwave™. Individual HPC licenses are available for single cores. A single HPC pack unlocks eight cores for a single user, two packs unlock 32 cores, three packs unlock 128 cores, four packs unlock 528 cores and five packs unlock 2048 cores. HPC Workgroup license packs offer access to 128 to 2,048 cores shared across any number of users.

Conclusion

HPC improvements in ANSYS HFSS technology reduce solution times so organizations can consider more design alternatives in less time. These improvements also make it possible to solve larger and more complex models in a shorter period of time to provide a clearer picture of full-system performance and higher levels of fidelity. HPC also enables companies to utilize design optimization and robust design methods to deliver dramatic improvements in product performance and reliability. All in all, HFSS can provide an important competitive advantage for companies looking to optimize the performance of their products and reduce time to market.

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