### Ansys HFSS Getting Started LE7

## Module 7: Optimetrics and High-Performance Computing (HPC)

Release 2020 R2



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# **Outline - High Performance Computing (HPC) and Optimetrics**

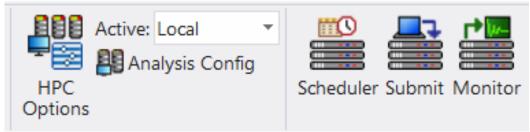
#### • DDM and SDM

- Domain Decomposition Method (DDM)
- Spectral Decomposition Method

#### • HPC Settings

- HPC Setup Up Add Edit
- Use Automatic versus Manual Settings
- Optimetrics
  - Parameter Sweep with
  - Tuning with Analytic Derivatives
  - Optimization

#### Help



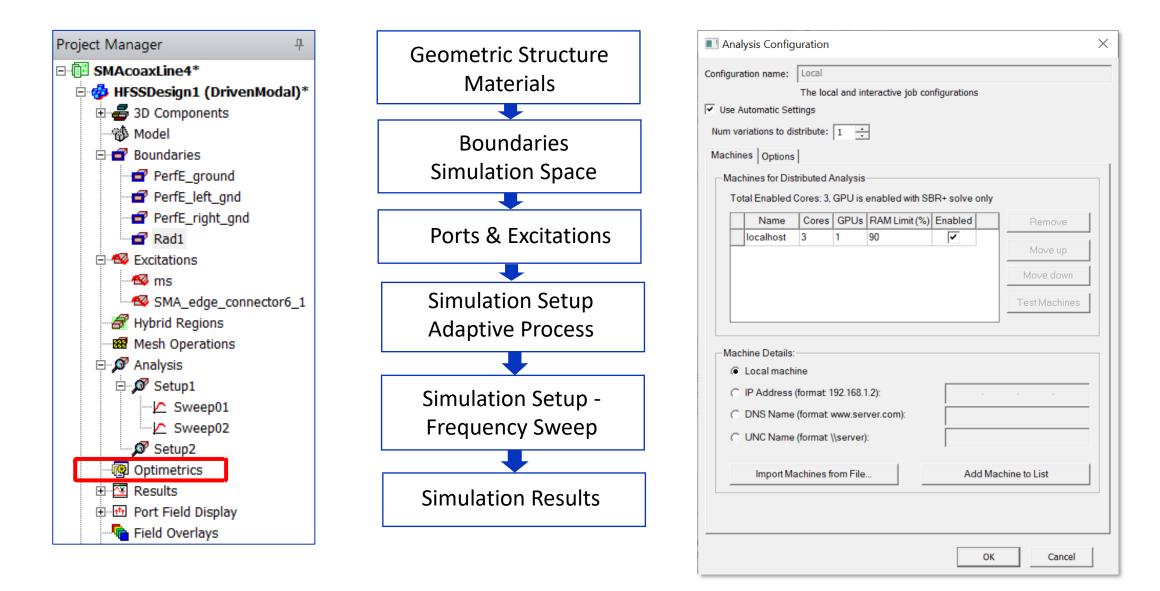
HPC refers collectively to features that access additional computing resources to either allow larger HFSS simulations or improve the simulation speed of a given HFSS simulation.

Additional detailed information on *Optimetrics* is available in the Help document *HFSS.pdf*. See chapter on *Optimetrics*.

The document *An Introduction to HFSS*, is available in the installation directories */Help/HFSS/GSG*. See Chapter 4 *HFSS Solution Setup > HPC and Analysis Options*.



## **Optimetrics and HPC in the HFSS Simulation Workflow**





# HPC: Multi-Threading (MT)

Multi-Threading (HPC-MT)

- Single workstation solution
- Many tasks of the solution process
  - TAU Initial Mesh Generation
  - Direct Matrix Solver
  - Iterative Solver
  - Field Recovery
- Available in HFSS, HFSS 3D Layout and HFSS-Transient design types

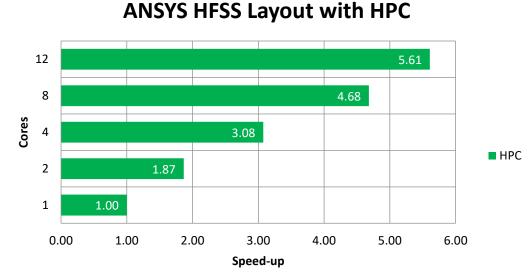
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Profile	Convergence Matrix Data	
	Task	
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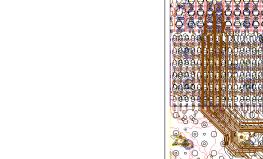


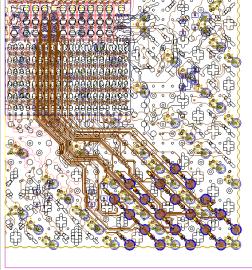


Thread 1 Thread 2

Thread 3 Thread 4







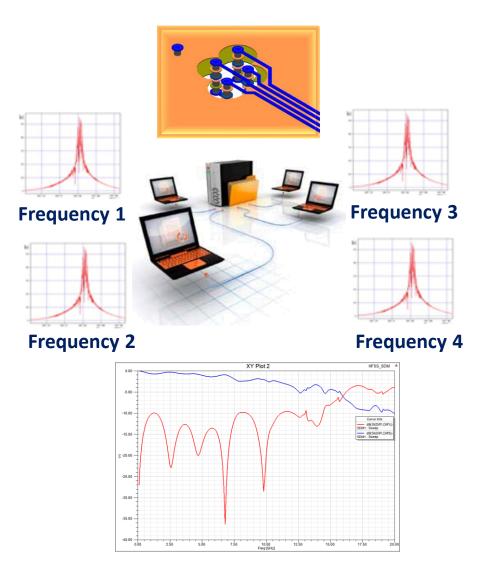


## **HPC: Distributed Frequency Solutions - DSO**

#### **Distributed Frequency Solutions**

- Distributes frequency points in frequency sweeps across a network of processors or on a single computer.
- Uses MPI (message passing interface)
- Scalable to large numbers of cores
- Available in HFSS and HFSS 3D Layout design types

Analysis Configuration	
Configuration name: Local	
The local and	d interactive job configurations
Machines Job Distribution Opti Enable Distribution Types:	ons
<ul> <li>✓ Optimetrics Variations</li> <li>✓ Frequencies</li> </ul>	This menu comes from the HPC
<ul> <li>✓ I ransient Excitations</li> <li>✓ Domain Solver</li> <li>☐ Iterative Solver Excitations</li> <li>☐ Direct Solver Memory</li> </ul>	and Analysis Options dialog box when you click on Edit and choo the Job Distribution tab.



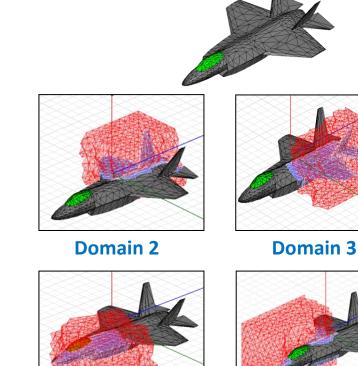


## DDM (Mesh Based) - Domain Decomposition Method

HFSS can partition a design into domains simulating different parts of the overall mesh separately

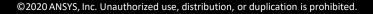
- A large problem domain is partitioned into small sub-domains.
   (A large mesh is broken down into small sub-meshes.)
- Each sub-mesh or sub-domain is solved in a separate core or a set of shared cores on a single computer or spread across multiple computers in a network.
- An iterative procedure combines the separate results into a single solution that gives the complete response for the entire model.

For DDM context and introduction, see *HFSS.pdf*, chapter on *Specifying Solution Settings > Setting Adaptive Analysis Parameters for HFSS > Enable Domain Decomposition*.



Domain 1

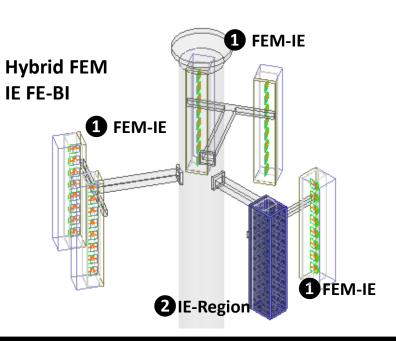
**Domain 4** 

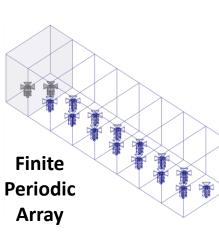


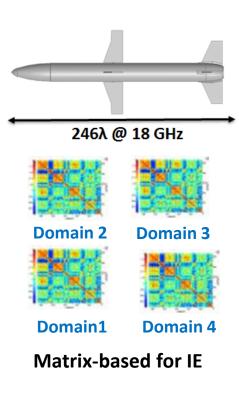


## DDM with IE Regions, Finite Arrays, and Hybrid Regions

- Domain Decomposition Method: Matrix Based (Integral Equation Solver)
- Domain Decomposition Method for Hybrid Solve (e.g. FEM/IE/FEBI)
  - FEM volume can be sub-divided into multiple domains.
  - IE Domains and FEBI boundaries will be distributed to separate nodes when they become large.
- Periodic Domain Decomposition Method for Finite Array Antennas (FADDM)
  - Automatic generation of domains
  - Available in HFSS 3D with Model Array defined







For more information, please see *HFSS Online Help > Specifying Solution Settings > Setting Adaptive Analysis Parameters for HFSS > Enable Domain Decomposition.* 



## HPC Setup - Add Edit Buttons

Modeler HFSS Tools Window	Active: Local	The local and interactive job configurations          Image: Settings       Local machine typical configuration using most all available cores and RA         Machines for Distributed Analysis
HPC and Analysis Options onfigurations Options Design Type:  HFSS	There can be multiple HPC configurations.	Name       Cores       RAM Limit (%)       Enabled       Remove         localhost       7       90       Image: Cores       Move up         Move down       Test Machines       Test Machines
vailable Configurations:ActiveNameTotal TasksTESLocalAutoThis menu is also available from Tools > Options > HPC and Analysis Options.	Make Active       Configuration Details:         Make Active       Configuration Name:         Local (Auto)       Local (Auto)         Add       Machine List         Edit       Job Distribution:         Delete       Optimetrics variations will be solved sequentially.         Other distribution types will be distributed automatic         Options:         AllowOffCore : True	Machine Details:

Analysis Configuration

See also the online Help document *HFSS.pdf* chapter 6 *High Performance Computing*.



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### **Analysis Configuration: Manual vs. Automatic**

<ul> <li>Analysis Configuration</li> <li>Configuration name: Local         <ul> <li>The local and interactive job configurations</li> <li>Vise Automatic Settings</li> </ul> </li> <li>Num variations to distribute: 4 ÷</li> <li>Machines Options</li> <li>Machines for Distributed Analysis         <ul> <li>Total Enabled Cores: 7</li> </ul> </li> </ul>	× With Use Automatic Settings checked, HFSS looks at resources and intelligently choose how to distribute simulations.
Name       Cores       RAM Limit (%)       Enabled         localhost       7       90       Image: Cores       Image: Cores         Machine Details:       Image: Cores       Image: Cores       Image: Cores       Image: Cores	Remove Move up Move down Test Machines
<ul> <li>Local machine</li> <li>When Use Automatic Settings</li> <li>Job Distribution does not app</li> <li>Tasks are not available.</li> <li>Num variations to distribute Optimetrics distribution.</li> </ul>	pear.
-	DK Cancel

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## For Job Distribution...Uncheck Use Automatic Settings

Analysis Configuration     X
Configuration name: Local The local and interactive job configurations
Use Automatic Settings
Machines Job Distribution Dptions
Enable Distribution Types:
Optimetrics Variations
✓Frequencies ✓Transient Excitations
M Domain Solver
□ Iterative Solver Excitations
Direct Solver Memory
Distribution levels:
Single level only     Level 1
C Enable two level      Distributed solutions at first level:
One distribution type will be applied at each stage of the solution process. If multiple types are available, the higher level solution will generally be distributed. All machine tasks will be used by the single-level distribution.
Preview Job Distribution Setup:  PHFSSDesign1:Setup1
Setup1: Sweep distributing Frequencies
OK Cancel

- Many settings under *Job Distributions*
  - Use Automatic Settings needs to be unchecked.
  - A number of *Tasks* above 1 must be specified in *Machines* tab.
  - This menu on left indicates frequency distribution.

Analysis Configuration	×
Configuration name: Local	
The local and interactive job configurations	
Use Automatic Settings	
Machines Job Distribution Options	
Machines for Distributed Analysis	1
Total Enabled Tasks: 4 Total Enabled Cores: 7	
Name Tasks Cores RAM Limit ( Enabled Remove	
localhost 4 7 90 🗹	
Move up	

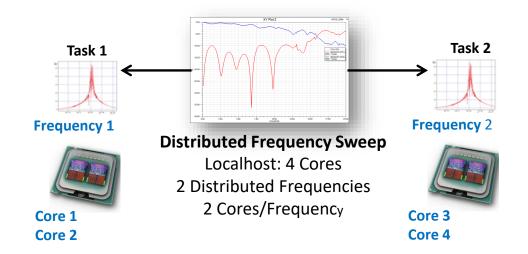
If *Tasks* under *Machine* tab is left at 1, then one won't see distribution here under Job Distribution tab.



## HPC Frequency Sweeps - Adaptive Mesh on One Machine

#### HPC for Frequency Sweeps

- Machine Details:
  - Cores: Total number of cores on the machine
  - Supports multiple machines
- Job Distribution:
  - Tasks: how many distributed frequency points will be launched per machine
  - If *Tasks* < *Cores*, the remaining cores will be used to accelerate the solver
  - Distribution Type: Frequencies.
- Adaptive Mesh Process
  - Since the *adaptive mesh process only supports a single machine*, the solve will automatically be run on the first machine in the list. All the available cores on that machine will be used for multi-threading during adaptive process.



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Configura	ition name:	Local					
Use A	utomatic Sett	tings					
Machine	es Job Distr	ibution	Options	1			
Mach	nines for Distri	buted Ar	alysis –				
Tota	al Enabled Ta	isks: 2 T	otal Ena	abled Cores: 4			
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are ava used by Preview	w Job Distribu	tion Set	up:		_Solution	ОК	Cancel



## **Analysis Configuration:** Manual vs. Automatic

- Automatic Settings of Analysis configurations
  - Indicate machines and total number of cores per machine to use in simulations
  - HFSS decides how to distribute tasks.

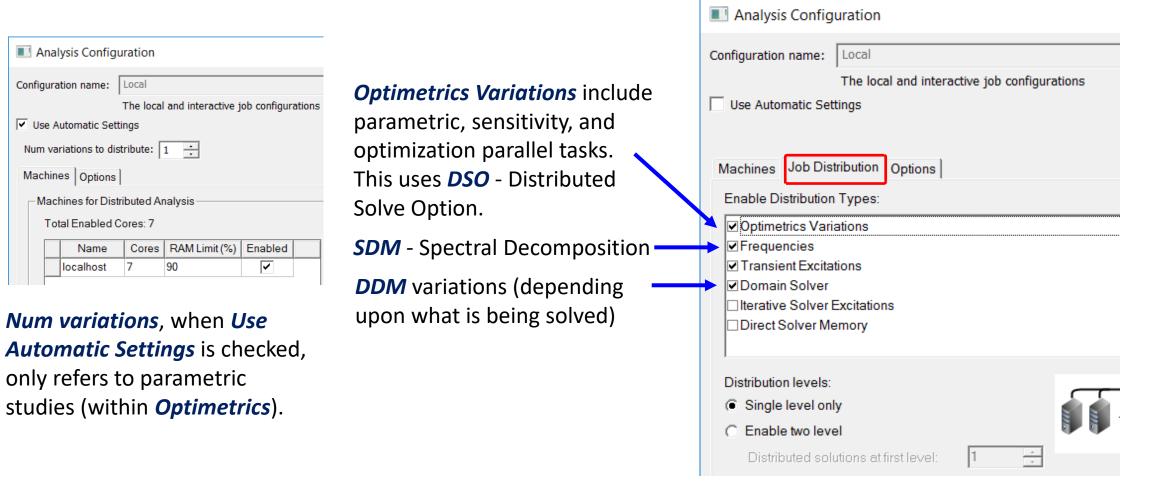
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To	tal Enabled Core	s: 40						
	Name	Cores	RAM Limit (%)	Enabled	Remove			
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C	UNC Name (for	mat: \\sei	rver):					
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_	Import Machines from File Add Machine to List							
				0	K Cancel			

- Default Settings of Analysis configurations
  - Indicate machines, tasks and total number of cores per machine to use in simulations
  - Indicate Job Distribution

Analysis Configuration
Configuration name: FEM
Use Automatic Settings
Machines Job Distribution Options
Enable Distribution Types:
Distribution levels:
C Enable two level Distributed solutions at first level: 2
One distribution type will be applied at each stage of the solution process. If multiple types are available, the higher level solution will generally be distributed. All machine tasks will be used by the single-level distribution.
Preview Job Distribution Setup: PHFSSDesign1:Setup1
Setup1 : LastAdaptive distributing Domain Solver Setup1 : Sweep1 distributing Domain Solver
OK Cancel

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## Num Variations and Job Distribution

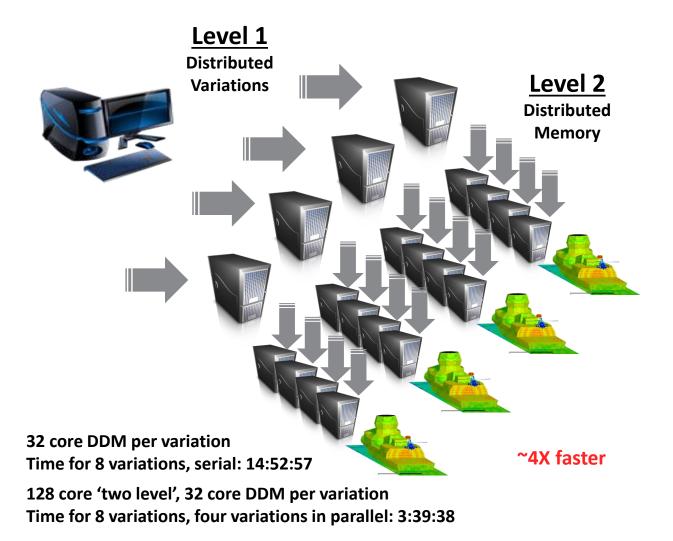


**DSO** - a licensing option - refers to multiple instances. **DSO** is what allows a user to choose **Num variations** above 1.



## Multi-level HPC for Speed <u>and</u> Scale

Analysis Configuration
Configuration name: 2 level optimetrics DDM
Use Automatic Settings
Machines Job Distribution Options
Enable Distribution Types:
<ul> <li>✓ Optimetrics Variations</li> <li>□ Frequencies</li> <li>□ Transient Excitations</li> <li>✓ Domain Solver</li> <li>□ Iterative Solver Excitations</li> <li>□ Direct Solver Memory</li> </ul>
Distribution levels: Single level only The first level will distribute the specified number of solutions. Each solution will use a subset of machine tasks to distribute the second level. A solver distribution type must be available for the second level, otherwise single-level distribution will be applied.
Preview Job Distribution Setup: III HFSSDesign 1:Parametric Setup 1
Parametric Setup 1 distributing two levels         Level 1 - Optimetrics Variations         Level 2 - Setup 1 : LastAdaptive - Domain Solver         Level 2 - Setup 1 : Sweep 1 - Domain Solver
OK Cancel



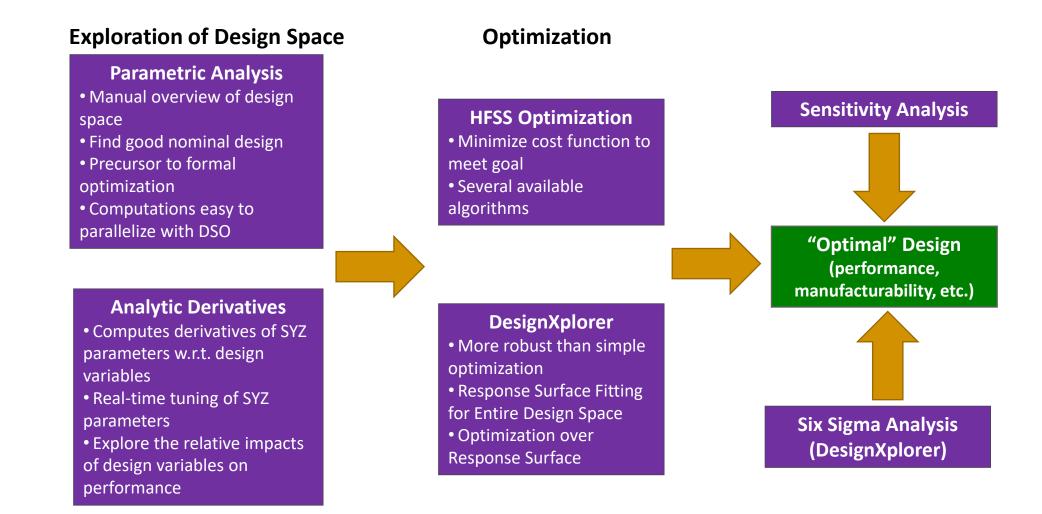
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# **Optimetrics** Introduction

- Optimetrics is now included with all premium and enterprise licenses.
  - Parametric
  - Optimization
  - Sensitivity
  - Statistical
  - Tuning
  - Analytic Derivatives
  - Enables ANSYS DesignXplorer Link
- Optimetrics allows centralized control of design iterations from one common interface
- Optimetrics allows the user to:
  - Automate parametric sweeps
  - Perform real time parameter tuning using Analytic Derivatives
  - Identify performance specifications to optimize
  - Perform sensitivity and statistical analysis on optimized model
  - Link to DesignXplorer for
    - Optimization via a Surface Response using Design of Experiments (DOE)
    - Six Sigma Analysis



## Robust Design using Optimetrics Tools



Robust Design is MORE than simple optimization: it is the ability for a user to systematically explore an entire design space so as to arrive at an optimal design.

# Using Optimetrics

- Process
  - Create parameterized model
  - Define design parameters to vary
  - Model geometry, material properties, etc.
  - Perform analyses
- Where can Optimetrics be used?
  - User may apply parameterization at all modeling stages
    - Geometry (size, shape, orientation, quantity, etc.)
    - Materials (lossless, complex, anisotropic, etc.)
    - Boundaries (impedance/conductance boundaries, linked boundary scan angles, symmetry or mode cases, etc.)
    - Solution setup
    - Post Processing Quantities (Port magnitude/phase, De-embedding, etc.)
  - Once model is parameterized, optimization can be performed toward an extensive array of cost functions
    - Circuit parameters (S, Z, or Y-parameters)
    - Antenna patterns (Directivity, gain, axial ratio, etc.)
    - Emissions
    - Derived field quantities (radiated power, etc.)

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## **End of Presentation**

