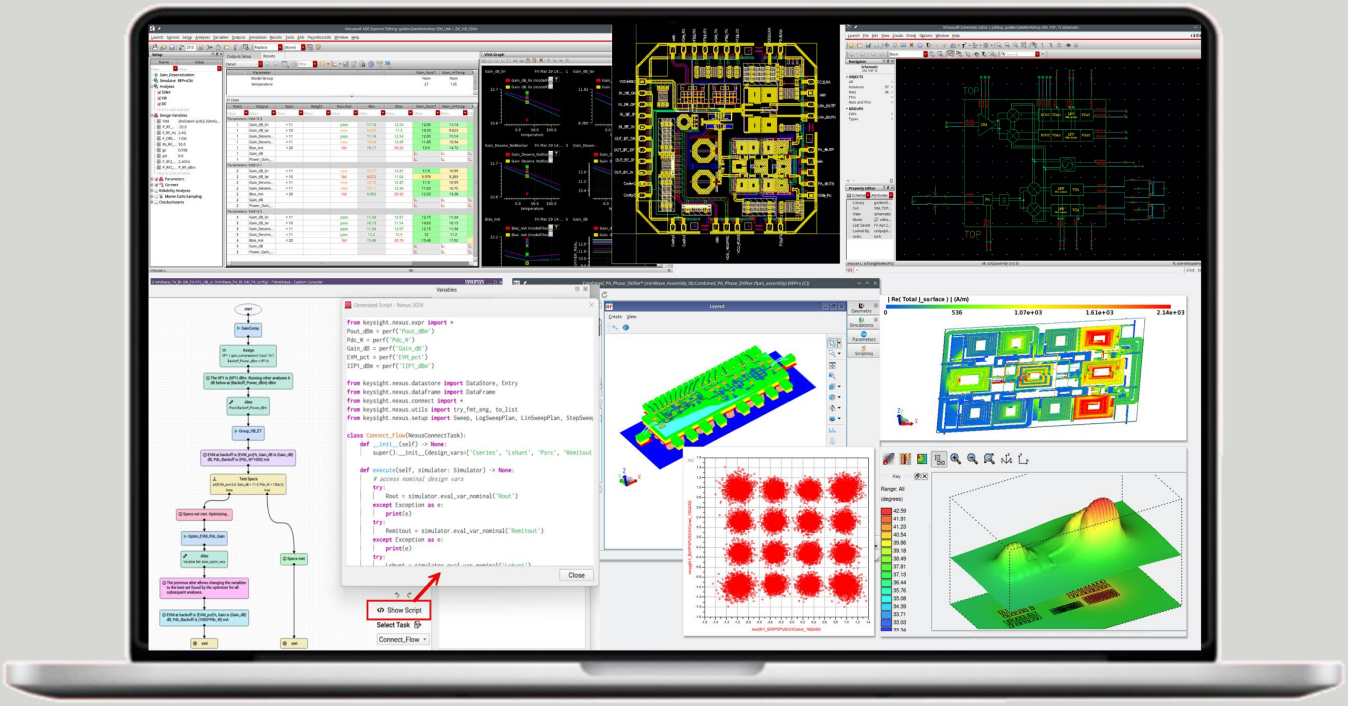
PRODUCT BROCHURE



RF Circuit Simulation Professional (Nexus)

Next Generation RF Circuit Simulation and Optimization Software

For Designing RF-Microwave-mmWave Circuits, RFICs and 3D Heterogenous Integrated (3DHI) Modules

KEYSIGHT

Overview

- RF Circuit Simulation Professional (Nexus) revamps circuit simulation and optimization technology for efficient and accurate design of the most challenging RF-microwave-mmWave circuits, RFICs, and RF 3D Heterogeneous Integrated (3DHI) modules for 5G/6G, wireless, radar, and defense-aerospace applications.
- Nexus flow-based User Interface (UI) orchestrates disjoint simulation and optimization tasks into intuitive analysis workflows that can be saved, shared, and reused. The Nexus UI and workflows work identically in the industry's most trusted EDA platforms: Keysight Advanced Design System (ADS), Cadence Virtuoso, and Synopsys Custom Compiler. Nexus eliminates unproductive repeat analysis setups across design teams and different design platforms to maximize collaboration and productivity. See Figure 1.
- Breakthrough Nexus Connect visual flowchart documents and executes your RF design flow. It automates design decisions based on prior results and eliminates idle wait times by triggering the next simulation or optimization branch immediately based on specific results. Nexus Connect visual workflow creates Python scripts behind the scenes to capture design expertise into structured data for reuse and for AI training in future. See Figure 2.
- Nexus offers multi-domain circuit simulation algorithms to thoroughly characterize the multi-spec requirements that a design must simultaneously satisfy, e.g., efficiency, error vector magnitude (EVM), Adjacent Channel Leakage Ratio (ACLR), stability margin, gain, output power, and wireless 5G/6G standards compliance.
- Unlike traditional circuit optimizers, Nexus optimization algorithms operate on challenging designs with large-scale variable counts, such as RFICs and 3DHI transceiver modules, to converge on multiple performance goals with up to 30x speedup. Nexus can also exploit available parallel computing resources to accelerate convergence by as much as 16x.
- Python automation makes Nexus AI-ready to leverage machine learning models, e.g., Artificial Neural Networks (ANN), Large Language Models (LLM), and integration with external AI algorithms and frameworks, such as copilots and AI agents, to realize unprecedented productivity.

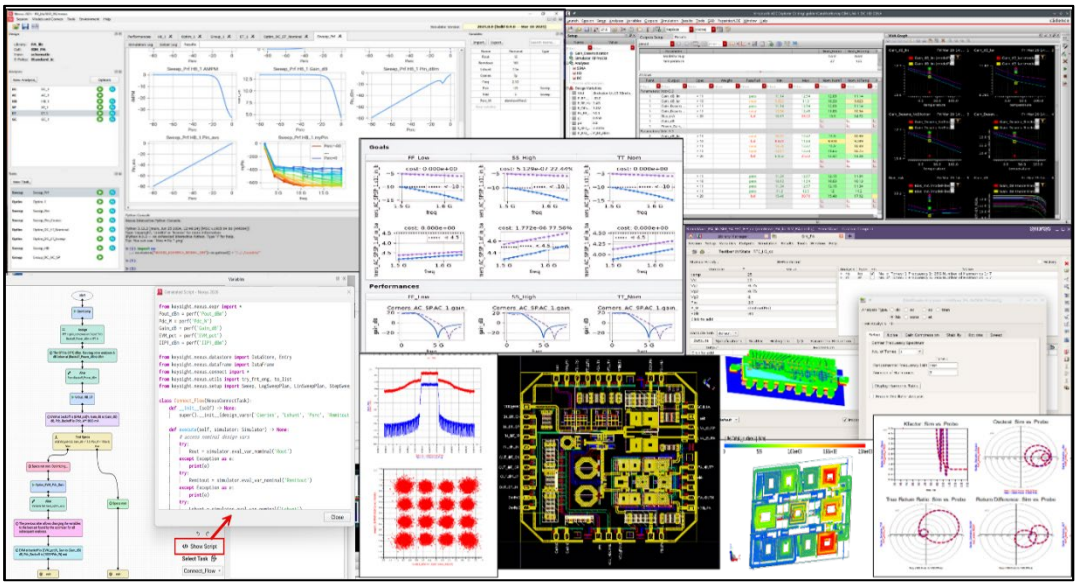


Figure 1. Nexus RF-MW-mmWave simulation and optimization EDA software provides the highest accuracy, speed, and confidence in designing circuits, RFICs, and 3D Heterogenous Integrated (3DHI) modules.

Nexus Workflow-Based User Interface (UI)

Unlike traditional single-task-oriented simulation and optimization control, the Nexus workflow-based UI integrates all required simulation tasks into an intuitive and organized workflow. It orchestrates multi-domain (e.g., time, frequency, envelope, electrothermal, statistical, measurement) simulation algorithms deployment across design hierarchies for thorough characterization of performance and corner cases of even the most complex designs. See Figure 2.

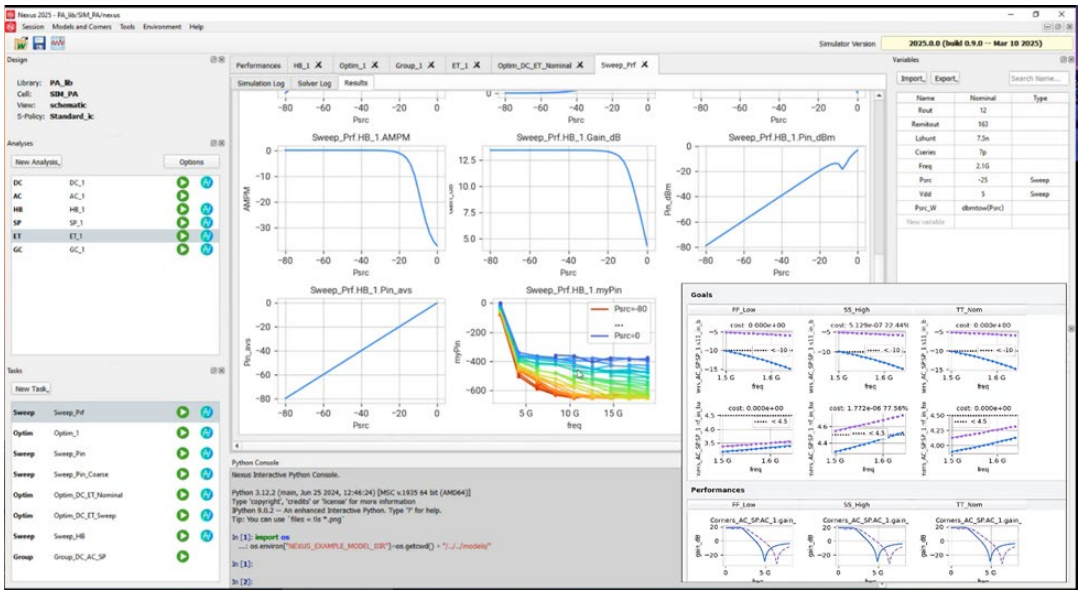


Figure 2. Nexus UI organizes simulation and optimization control as workflows instead of disjointed tasks to closely capture the designer's thought process in producing a design. The integrated Python console enables interactive and quick viewing of computed results to provide instant feedback on whether all required performance specs have been simulated and optimized.

- Breakthrough workflow-based Multi-Domain Simulation and Optimization UI with integrated Python console
- Nexus UI replaces disjointed simulation and optimization tasks with intuitive analysis workflows.
- Simulation and optimization workflows can be saved together with associated variables and equations for reuse.
- Nexus workflow reuse eliminates wasteful repeat simulation setups and debugging.
- Customized libraries of reusable simulation and optimization workflows for specific design tasks maximize personal and enterprise design productivity.
- Nexus UI and its saved analysis workflows operate identically cross-platform with Keysight ADS, Cadence Virtuoso, thus enabling seamless collaboration across design teams working on circuit components, MMICs, RFICs, packaging and 3DHI module integration.
- Integrated Python console enables interactive communication with the simulator and the user interface for customization and programmatic control when it is embedded in a headless workflow
- Nexus user interface also allows adding functions and even homegrown or 3rd party optimizers through Python functions

Nexus Connect – Executable Whiteboard

Nexus Connect is an industry-first capability enabling RF engineers to capture design experience and methodologies into an executable whiteboard containing graphical flowcharts of simulations, optimizations, decision branches, and intermediate parameter settings.

Nexus Connect automatically generates Python scripts to self-document and replays the entire design strategy for technical review, workflow reuse, and full traceability of all design data.

- Organize and self-document design strategies.
- Instant recall by replaying any or all sections of the executable whiteboard.
- Streamline review and signoff with full design data traceability.
- Eliminate delays waiting for simulation or optimization to finish before deciding the next design step.
- Mitigate retiring RF talent loss by capturing precious design experience.
- Enterprise design methodology IP repository.
- Capture design methodologies into structured data for future agentic AI training and deployment.

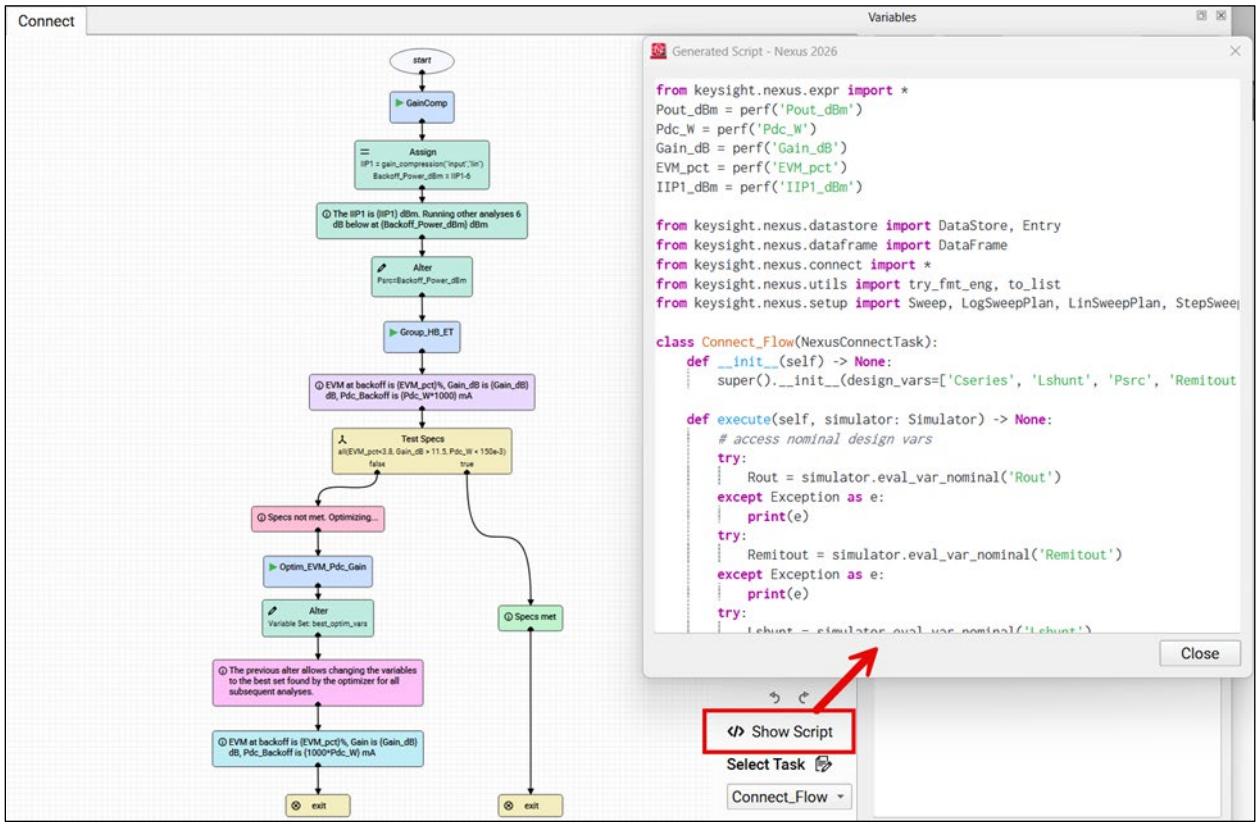


Figure 3. Nexus Connect enables a complete design methodology, including simulation, optimization, intermediate parameter settings, and decision branches, to be intuitively captured as an executable whiteboard. Nexus Connect automatically generates Python script to self-document the complete design workflow and can be modified to target other designs.

Nexus Multi-Domain Simulation Technologies

Designing RF-microwave-mmWave circuits, RFICs, and 3DHI modules for 5G/6G, wireless networking, radars, and defense-aerospace applications must always meet multi-spec requirements, such as efficiency, power, gain, EVM, ACLR, stability, and compliance with wireless standards. See Figure 4.

Nexus offers multiple simulation technologies, sequenced through its workflow-based UI to ensure thorough and accurate characterization of these multi-spec performances before tapeout to eliminate costly hardware respins.

Keysight Nexus simulators enjoy comprehensive Process Design Kit (PDK) support from the world's leading foundries for accurate RFIC, MMIC and 3DHI RF module designs, and successful tapeouts.

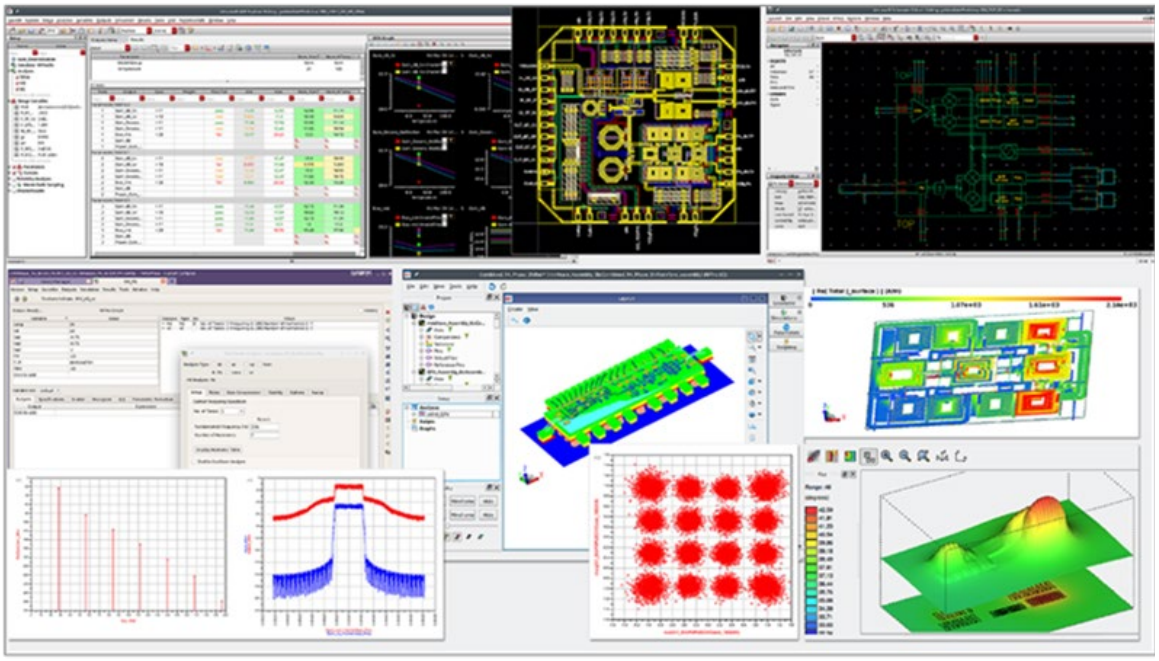


Figure 4. Nexus advanced multi-domain circuit simulation, optimization, and visualization capabilities are accessible from Keysight ADS, Cadence Virtuoso, and Synopsys Custom Compiler design platforms.

- Nexus' multiple circuit simulation algorithms operate across multiple domains (frequency, time, envelope, linear, nonlinear, stability, electrothermal, system and measurement) for thorough characterization to satisfy multi-spec design requirements.
- Multi-domain simulations can be customized (e.g., multi-dimensional sweeps), sequenced and saved as workflows to ensure all required performance specs are consistently analyzed thoroughly.
- Nexus circuit simulation can be accelerated by 16x through parallel runs on available compute resources.
- Unique, state-of-the-art simulation algorithms with superior convergence and speed:
  - Error Vector Magnitude (EVM) with digital RF modulated signal excitation.
  - Breakthrough Envelope-Transient simulator for modulated signal excitation.
  - Fast Envelope with memory effects under modulated signal excitation.
  - Winslow's nonlinear stability replaces 14 traditional stability analyses.

    - Unrivaled nonlinear Harmonic Balance steady state simulator.
- Multi-physics design with other Keysight simulators:
    - EM-circuit cosimulation with RFPro FEM and 3D planar Method of Moments.
    - Electrothermal (ETH) to account for dynamic and device thermal effects.
    - System-circuit co-design with Virtual Test Benches (VTB) for standards compliance.
- Wide foundry PDK support for RFIC, MMIC and 3DHI RF module designs and successful tapeouts.

Nexus Multi-Performance Parallel Optimization

Classical random and gradient optimization techniques are becoming inadequate for achieving multiple performance goals with high variable count due to slow and often premature convergence on local minima. Nexus introduces 10 new optimization algorithms, such as Particle Swarm and Corona Simulated Annealing, for larger-scale optimization with many variables. They converge up to 30x faster compared to legacy techniques.

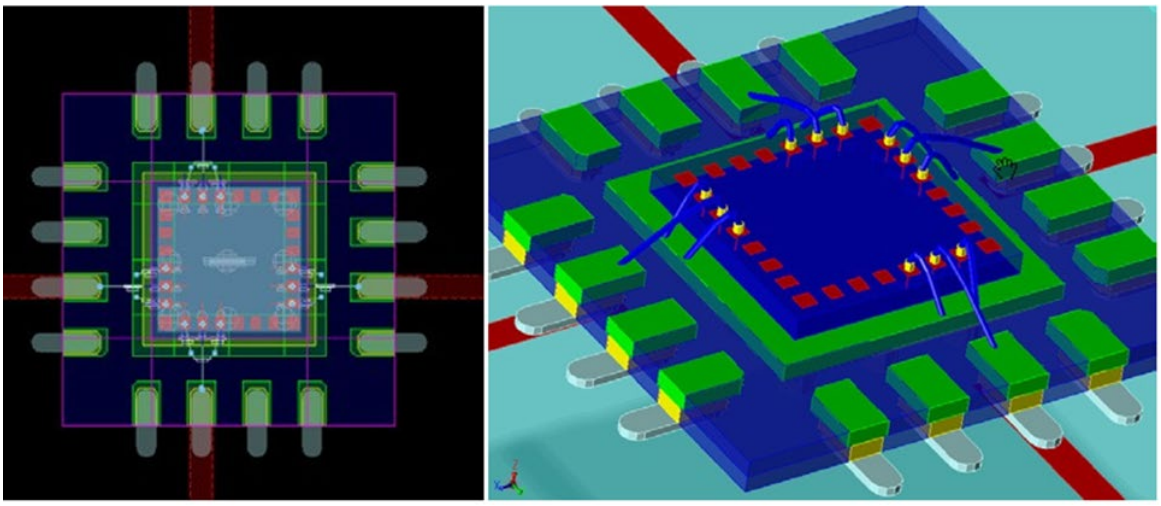


Figure 5. Optimize RFIC designed in Virtuoso or Custom Compiler together with off-chip 3DHI packaging and integration inside Keysight ADS.

- Optimization workflow control replaces disjointed optimization tasks by enabling conditional branching and sequencing of different design sections to be optimized in turn.
- Advanced optimization algorithms converge up to 30x faster while avoiding local minima traps.
- Parallel optimization with High-Performance Computing (HPC) clusters allow Nexus to accelerate convergence by up to 16x.
- Optimization performance goals can be specified with user-defined Python expressions.
- External Python-based optimization algorithms can also be used in Nexus to supplement the already powerful native optimizers.
- Common Open Access (OA) database enables RFICs designed in Virtuoso or Custom Compiler to be optimized together with off-chip packaging or in 3DHI module using Nexus and RFPro in ADS. See Figure 5.

Nexus Optimization Algorithms

Nexus provides 11 powerful optimization algorithms for different classes of problems. In addition, external Python-based optimization algorithms can also be used through Nexus open Python API.

- **CMA-ES** covariance matrix adaptation – evolution strategy
  - Adapts the shape, direction, and rotation of search space from sampling many candidate solutions from a multivariate Gaussian distribution and keeping the best-performing ones.
  - Learns how variables correlate in a noisy population and does not require gradients to direct search directions but adapts its covariance matrix to efficiently search complex continuous parameter spaces while optimizing.
  - Useful when evaluations are computationally expensive and gradients are not reliable or accessible.
- **Corana** Simulated Annealing (SA)
  - Inspired by metallurgical annealing, where a heated material is slowly cooled to remove defects, based on a predefined cooling schedule (e.g., exponential, or logarithmic) which controls the probability of escaping local minima traps.
  - Corana has improved convergence over traditional SA techniques by employing adaptive step size search. For large-scale optimization where a desired global extremum is hidden among many poorer, local extrema.
- **PSO** particle swarm optimization
  - Inspired by the social behavior of birds flocking or fish schooling, where a population of candidate solutions, called particles, move around in the search space. The movement is directed by the best-known positions of itself and other particles. See Figure 6.
  - For a wide range of optimization problems with a high-dimensional search space, because it is gradient-free to handle non-differentiable functions and avoids local minima traps.

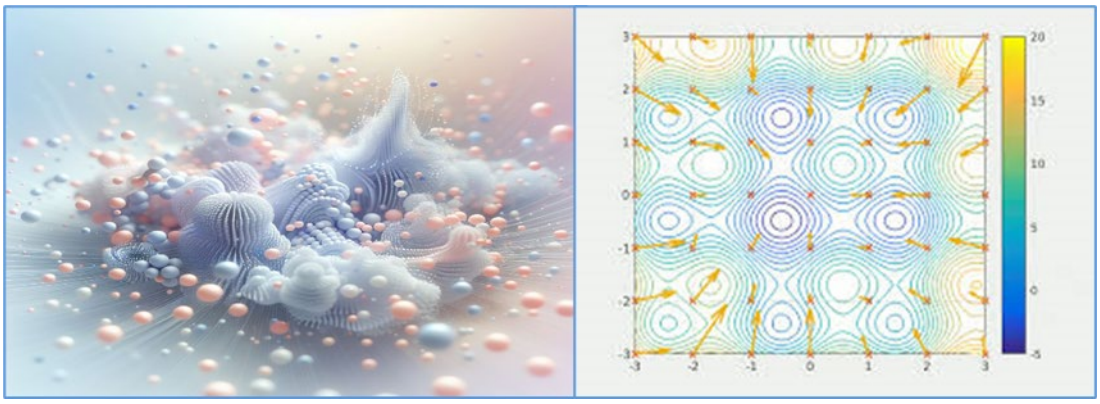


Figure 6. Particle Swarm Optimization is suited for large scale problems and avoids local minima traps. *Graphics credits: Copilot and Wikipedia*

- **StoGO** stochastic global optimization
  - Divides the global search space into smaller ones for local gradient search with stochastic randomness.
  - For high-dimensional nonlinear objective problems that may contain multiple local minima.
- **CRS** controlled random search with local mutation

    - Does not require gradient information and makes small, random adjustments to the optimized points, to fine-tune the search around promising areas to avoid local minima traps.
    - For a wide range of optimization problems where the objective function is complex, nonlinear, or has many local minima.
- **LBFGS** low storage Broyden–Fletcher–Goldfarb–Shanno
    - L-BFGS is a quasi-Newton method that approximates the BFGS algorithm by using less memory. It minimizes a differentiable scalar function by iteratively improving the solution.
    - For large-scale optimization with many variables due to the linear memory and low storage requirement.
- **COBYLA** constrained optimization by linear approximations
    - COBYLA is a derivative-free optimization that approximates the objective and constraint functions using linear interpolation. Useful for problems with noisy data where derivatives are unavailable or computationally expensive to obtain.
    - For medium-scale problems with inequality constraints.
- **SLSQP** sequential least squares quadratic programming
    - SLSQP is gradient-based and solves a sequence of quadratic programming subproblems to find the minimum of a function subject to equality and inequality constraints.
    - For medium-scale nonlinear optimization problems with both equality and inequality constraints. Ideal where the objective function and constraints are twice continuously differentiable.
- **TNewton** truncated Newton
    - TNewton uses iterative approximations to Newton classical optimization method and avoids the computationally expensive Hessian matrix.
    - For large-scale unconstrained nonlinear optimization with many variables.
- **BOBYQA** bound optimization by quadratic approximation
    - BOBYQA is a derivative-free optimization and is ideal where the objective function is complex or noisy from simulation or measurements, making derivative calculations impractical.
    - For small to medium-sized problems with bound constraints, find a function's maximum or minimum within specific bounds.
- **SBPLX** subplex
    - SBPLX is derivative-free and more efficient than the original Nelder-Mead simplex method, as it searches within the subspaces of the optimization problem.
    - For medium-sized problems with discontinuous objectives and bound constraints, and where variables are bound within specific limits.
- **Python** optimization libraries
    - Python’s extensive public libraries of external optimization algorithms can also be used in your optimization workflow, thanks to Nexus’ open architecture with Python API.
    - This option opens Nexus for use with your own categories of Python optimization algorithms:
        - Genetic-Evolutionary
        - Gradient-based
        - Derivative-free
        - Metaheuristic
        - Bayesian
        - Linear programming

- Quadratic programming
- Mixed integer programming
- Stochastic
- AI-enabled, e.g., reinforcement learning, surrogate modeling, LLM driven.

Nexus AI-ready with Python Automation

Nexus can be programmatically controlled with Python scripting for unrestricted workflow automation. This makes Nexus AI-ready to leverage machine learning models, e.g., Artificial Neural Networks (ANN), Large Language Models (LLM), and integration with external AI algorithms and frameworks, such as copilots and AI agents to realize unprecedented productivity. See Figure 7.

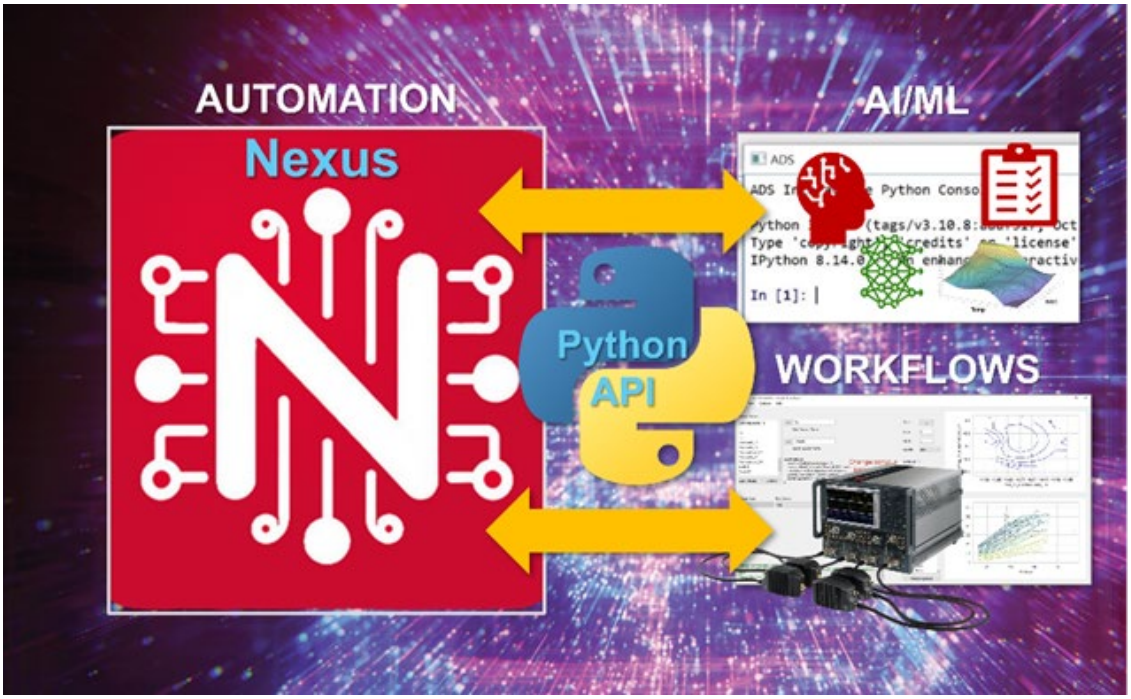


Figure 7. Python automation makes Nexus AI-ready to leverage machine learning models, and integration with external AI algorithms to realize unprecedented productivity.

- Nexus Python API enables programmatic control of simulation and optimization to automate workflows and to interact with external AI and Machine Learning (ML) frameworks to exploit the power of AI assisted designs.
- Python automation makes Nexus AI-ready to leverage machine learning models, e.g., Artificial Neural Networks (ANN), Large Language Models (LLM), and integration with external AI algorithms and frameworks, such as copilots and AI agents, to realize unprecedented productivity.

Nexus Configuration

Nexus is cost-effectively purchased as a shared pool of token licenses that are used during simulation or optimization and returned to the pool after a period of inactivity. Parallel simulation and optimization, delivering up to 16x speedup, can be enabled with a larger shared token license pool. See Figure 8.

A prerequisite design environment from the 3 listed below is needed by Nexus to run and to manage multiple designs. Nexus runs on the latest versions of Linux and Windows operating systems.

- **Prerequisite design environment**
  - Keysight Advanced Design System
  - Cadence Virtuoso ADE with Oasis Simulation Interface license
  - Synopsys PrimeWave Custom Compiler
- **W5600E** – Nexus RF Circuit Simulation Professional Element License
- **W5601E** – Nexus RF Circuit Simulation Professional 1 pack Element License

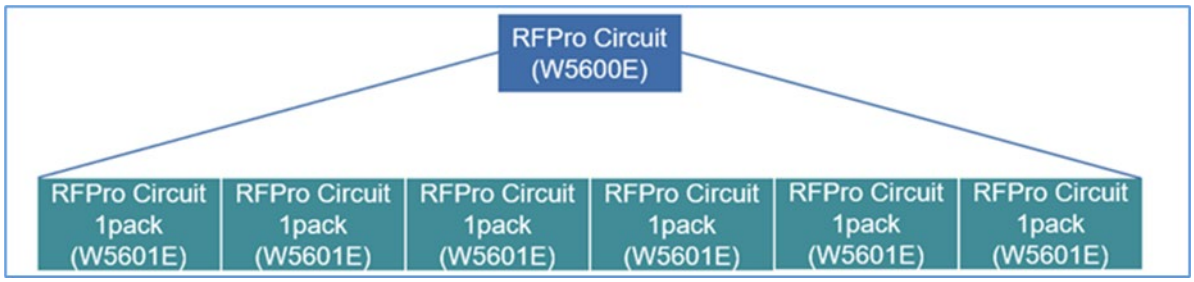


Figure 8. The W5600E Nexus element is the minimum recommended configuration. It contains six W5601E one-pack element licenses. The quantity of licenses can be scaled up to enable parallel simulation and optimization for 16x speedup and thorough simulation coverage before tapeout to eliminate costly respins.

Nexus Simulation Elements for Keysight ADS, Cadence Virtuoso and Synopsys Custom Compiler Design Flows

Advanced RF Circuit Simulation	
Keysight Nexus simulation suite (includes a total of six 1-packs)	W5600E
Keysight Nexus simulation 1-pack (a common expansion add-on)	W5601E
Electromagnetic Simulation	
Keysight RFPro (incl. Momentum and FEM Simulators)	W3030E
Electro-Thermal Simulation	
Keysight Electro-thermal simulator	W3050E
Keysight Electro-thermal dynamic model generator	W3051E
System-Circuit Verification Simulator and VTBs	
Keysight system-circuit verification simulator (incl. Ptolemy and VTB Engine)	W3040E
Keysight VTB engine	W3048E
Keysight radar VTB	W3041E
Keysight 5G and cellular VTB	W3042E
Keysight WiFi and connectivity VTB	W3043E
Keysight WiMedia, WVAN and DTV VTB	W3046E
Keysight complete VTBs	W3049E