

# Device Modeling MQA

Industry standard SPICE model validation software

## About Device Modeling MQA

Device Modeling MQA is a collection of comprehensive SPICE model validation procedures, interfaces, and utilities that provide the ability to thoroughly check SPICE model quality and automate QA and reporting procedures for both silicon and III-V technologies.

Given today's nanoscale process technologies and increasing model complexities, validating SPICE models is a significant challenge and can be very time-consuming. However, SPICE modeling engineers and model users still want the models to be thoroughly checked and the model characteristics to be easily obtained. MQA satisfies this critical industry requirement by rigorously checking the model quality, plotting model characteristics, and customizing the output targets with comprehensive checking rules while employing easy-to-use interfaces and utilities.



# Key Features

- Integrate a comprehensive set of rules to ensure SPICE model quality while overlaying measurements and simulation results
- Support for different commercial simulators to ensure the industry-standard simulation result.
- Rules and checking functions are flexible and fully customizable
- Customize user-defined plots and tables with Python script
- Measurement QA, model comparison, corner model QA, and Monte Carlo analysis
- Powerful plotting functions and utilities
- The open interface enables flexible support of models, simulators, and checking routines
- Complete parallelism support on different levels: simulator level, rule level, and project level
- Automatic QA report generation and customization
- Native support of MDM and MEA data formats
- Equipped with internal SPICE engine for fast simulation
- Easy project template management allows to re-use the configurations and build a custom model qualification process

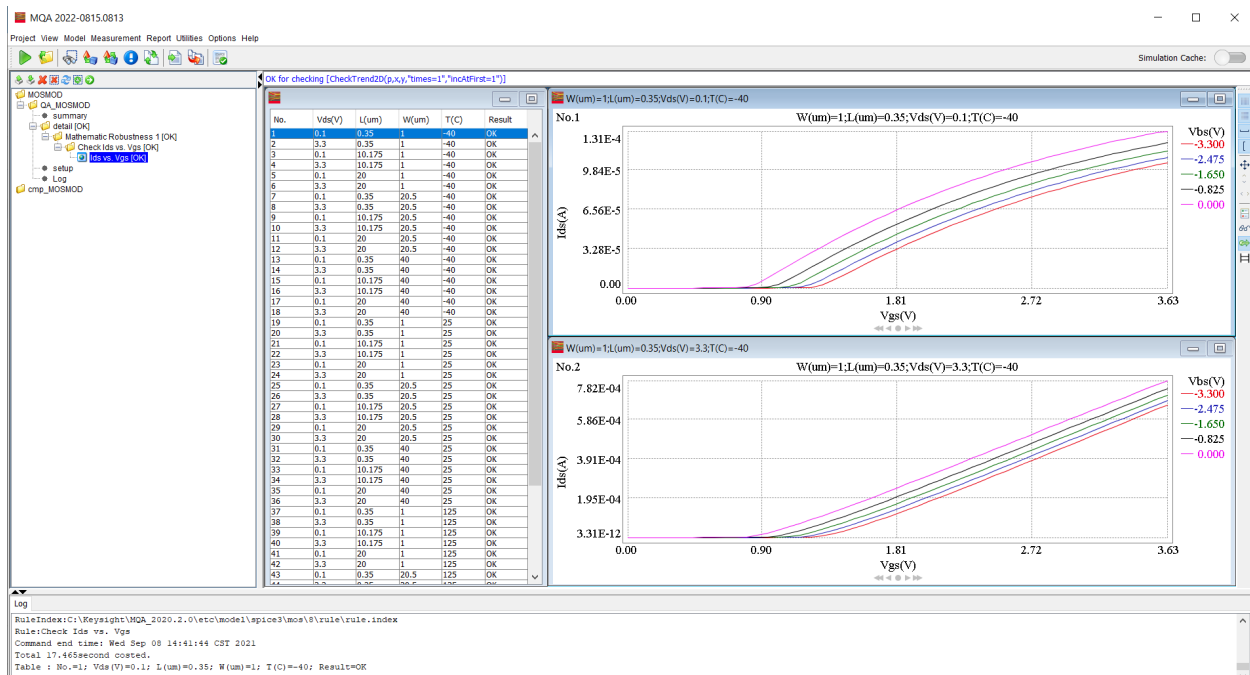


Figure1. Device Modeling MQA main GUI

# MQA Specifications

MQA is a unique software product developed to solve the following problems:

- SPICE model validation is becoming increasingly important and significantly more difficult.
  - As the channel scales down, second-order physical effects make device modeling more complex.
  - Macro(subckt) models and binning models are used extensively.
  - Validating these models is much trickier than global models.
  - A natural consequence of the foundry business requires a better way of communicating between modeling engineers and designers. Designers often need to check whether the models satisfy their requirements for some specific circuit design needs.
  - What appears to be a good model for certain applications can be a terrible one for others.
- Model validation involves much more than just overlaying the measurement results to the simulation results of the model.
  - The measurement is limited to the number of physical devices in the test structure and the resolution of instruments.
  - Model validation should include the following checks:
    - Accuracy of the model (compare with measurement).
    - Completeness of the model (have all the major physical effects important to the design been modeled?).
    - Mathematical robustness of the model (no kink in first and second derivative).
    - The capability of the model to predict physical trends (very important in design optimization).
    - Model simulation results using benchmark circuits.
- Model validation should be automatic and customizable.
  - The quality can only be guaranteed after fixed QA procedures are in place.
  - Manually validating a model is nearly impossible, considering a large number of checks for different device sizes, temperatures, and bias conditions.
  - Model reporting is often
  - time-consuming and should be expedited.
  - Model QA routines often change with model modifications; a customizable QA platform is needed.
  - QA tools should help users debug model issues and point out potential problems.

## Model QA

- Check model completeness
  - Is  $I_{sub}$ ,  $I_{gate}$ ,  $1/f$  noise, etc., covered in the model?
- Model parameter range check
- Check the trend of model characteristics
  - Verify that the trends of  $I_{dsat}$ ,  $V_{th}$ ,  $G_m$ ,  $G_{ds}$ , vs.  $W/L/T$  are correct
- Check the numerical robustness of the model
  - Any kinks in  $G_m$  or  $G_{ds}$  curves? Check bin continuity
- Check benchmark circuit performance
  - Ring Oscillators, for example
  - Users can input their circuits
- Calculate point simulation value according to user's specification
- Check model accuracy with the measurements
- Compare the model performance of different models, such as:
  - HSPICE model with Spectre model
  - BSIM3v3 model with BSIM4 model
  - Macro model with its core model
- Check and compare different process corners
- Check analog/RF design targets
  - Smith and polar chart plotting
  - Check the trend of network parameters
  - Load-pull and harmonic balance simulation and plotting
  - Thermal noise characterization
  - Support for multi-port QA

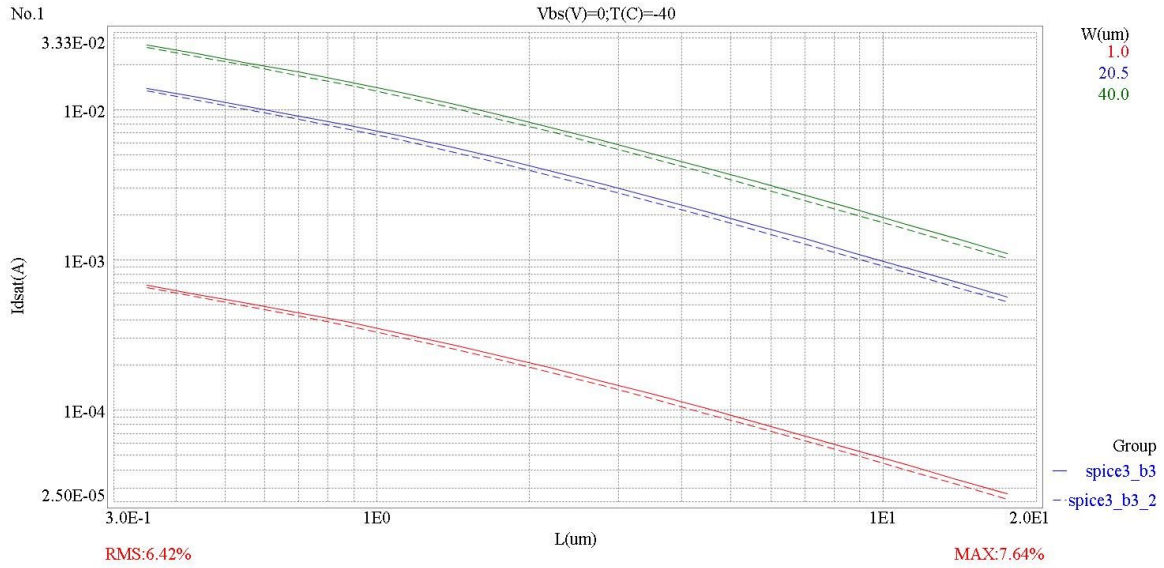


Figure2. Model comparison plot

## Measurement QA

- Quick display of measured device geometry and bias condition
- Plot measured device characteristics
- Check the trend of  $I_{dsat} * L$ ,  $I_{dsat} / W$ , and  $V_{th}$  to detect bad measurements

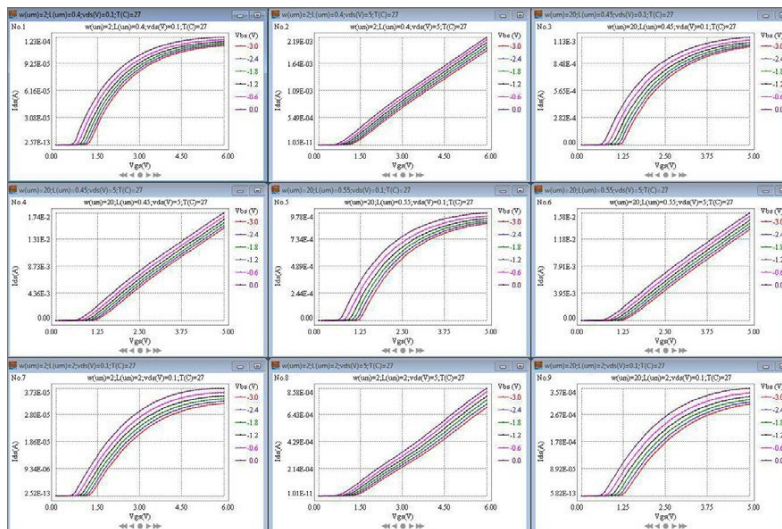


Figure3. Measurement QA plot

## Customizable checking rules

- Customize checking criteria and define the sweeping range
- Add your own rules and check new targets

## Open interface

- MQA provides an open interface for advanced users to utilize their math functions and data process functions.
  - Implement more math functions with little programming
  - Customize/add RMS functions of your preference
  - MQA's Java interface has an engine that enables users to edit, compile and debug their programs

## Powerful model reporting

MQA is equipped with a powerful report module:

- Easily output all desired tables and plots to a report format of the user's choice (i.e., Word, Excel, PowerPoint, HTML, PDF, or OpenOffice)
- Easily output all existing MQA plots to a report
- Report content is rule-driven and user-customizable

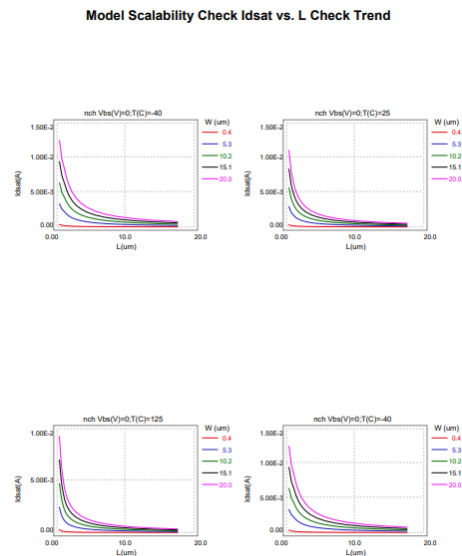
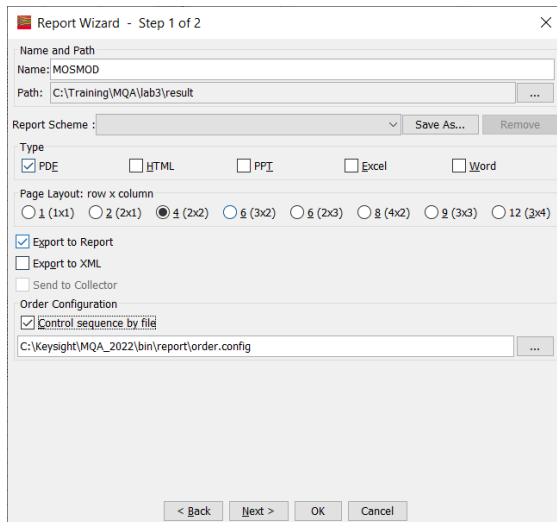


Figure4. Device Modeling MQA report function

# Powerful plotting

- Check scale, zoom in/out and digitalize the plots and apply math functions
- All plots can be saved to a graphic file
- The curves can also be displayed in a table
- Plot Smith Chart, polar chart, and noise figure
- Easily view the previously generated results
- Generate 3D plots

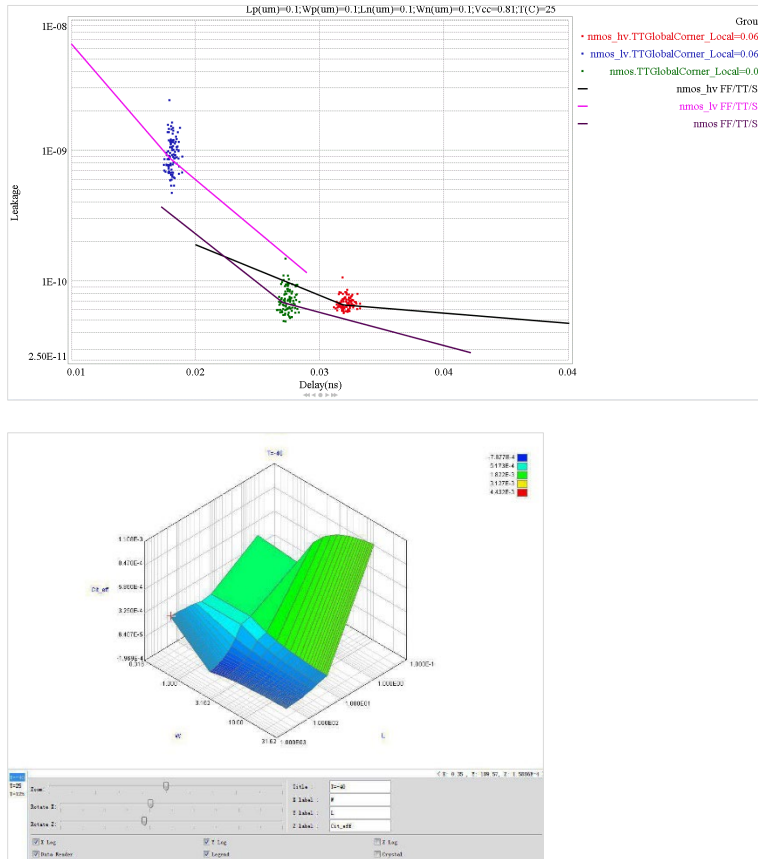


Figure5. Device Modeling MQA plotting function

# Post-processing with Python Script

- Generate customized plots and tables by post-processing MQA results
- No additional simulation is needed
- Enable target calculation and data processing
- Easily plug in existing user scripts

# Lib Explorer

Lib Explorer is an efficient way to present and set up model libraries. Within Lib Explorer, libraries are presented in a tree hierarchy, model configuration and settings can be done quickly, QA and Report projects are globally organized, and all effort can be saved, re-used, and accumulated

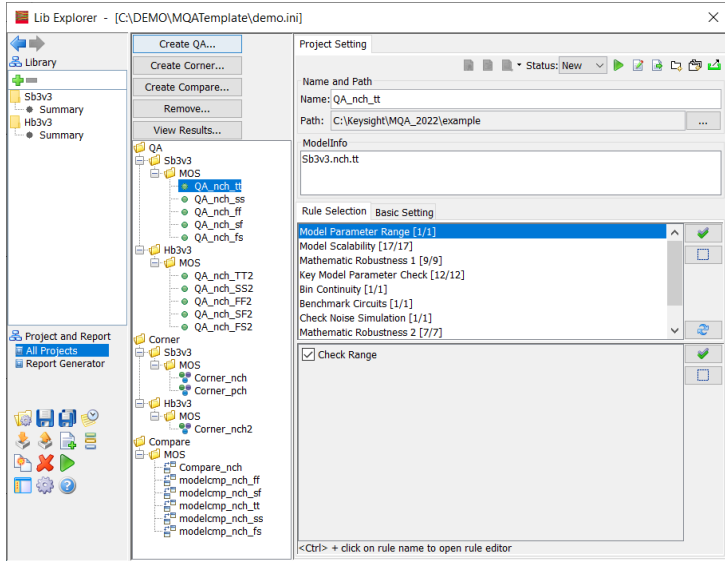


Figure6. Device Modeling MQA Lib Explorer main GUI

# Project template

Project template offers an easy way to generate a significant volume of new projects based on the existing template and new model library.

Project template examples offer a rich set of example QA projects.

- Create a template based on the Lib Explorer setup and apply it to the new model library
- Choose a template example and apply it to the new model library

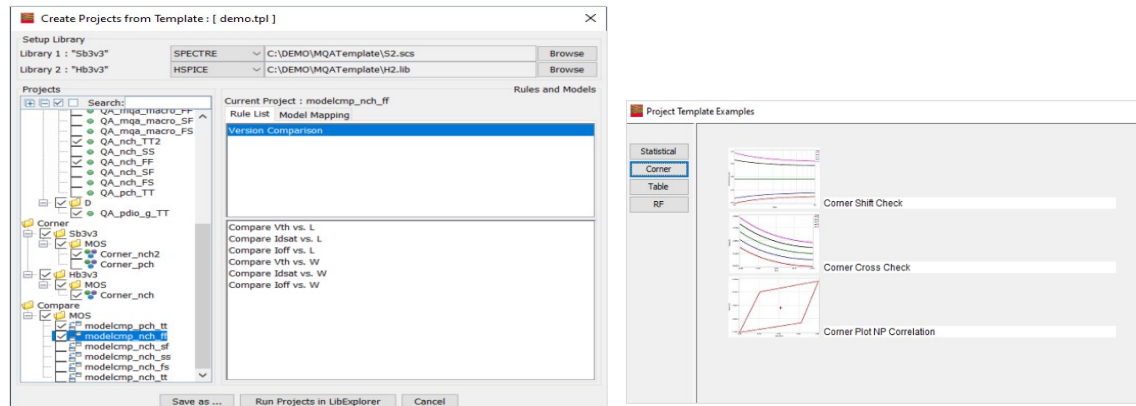


Figure7. Device Modeling MQA project template and examples

## Equation viewer

This feature outputs model equations and automatically calculates the equations' parameter values, OP values, and intermediate variable values. This function helps users easily debug model issues and saves effort compared to calculating these values using other means (such as Excel).

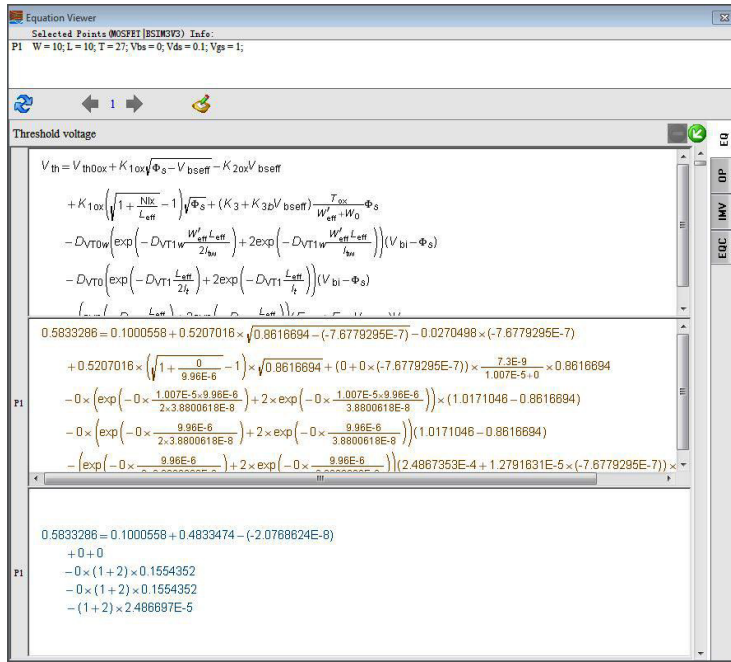


Figure8. Device Modeling MQA equation viewer

## Model tweaking

MQA enables you to tweak the model parameters and see the impact on the model performance. This function allows for model adjustment to adapt to a specific use.

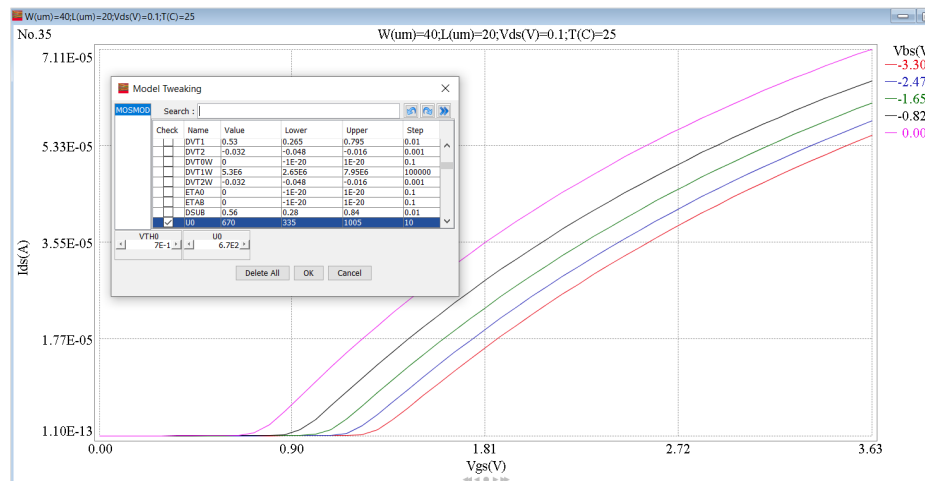


Figure9. Device Modeling MQA model tweaking

## Supports ET data

MQA enables you to load ET/PCM data and compare it with your simulation. The ET data can be overlaid with many simulation results in MQA.

## Integrated data flow

MQA natively supports the Device Modeling WPE/IC-CAP and Device Modeling MBP data formats. This enables a seamless data flow across Keysight's device modeling platform.

## MDM data filter

The MDM data filter utility can filter MDM data measured by IC-CAP WaferPro (WPRO) or WaferPro Express (WPE). The utility creates an MDM directory with the same hierarchical structure as the original directory, including only the selected subset of data.

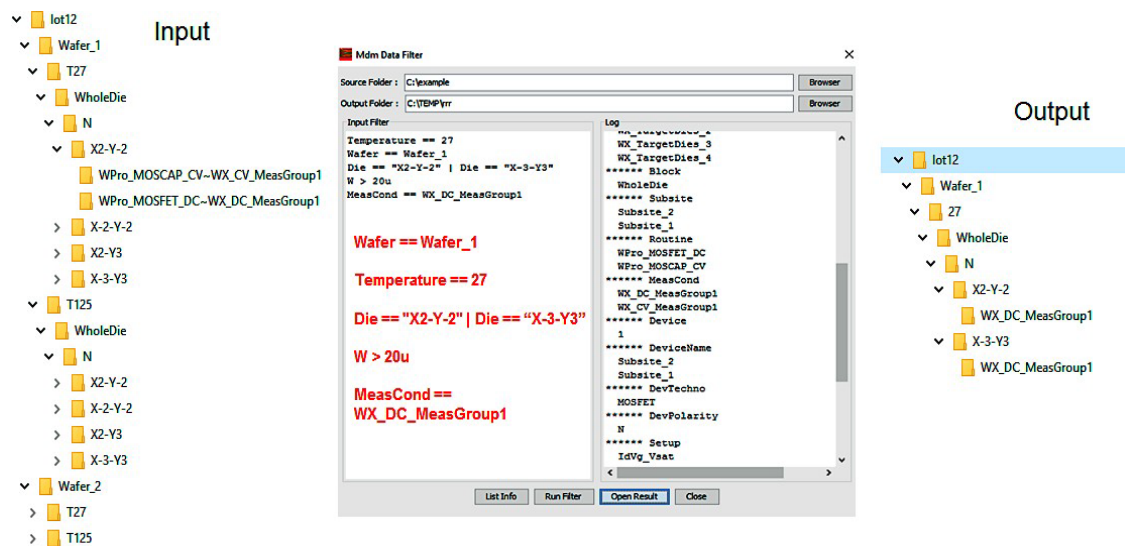


Figure10. Device Modeling MQA MDM data filter

## Speedup by Parallelism Support on Multiple Levels

MQA supports multiple-level parallelism, including simulator, rule, and project levels. It maximizes model QA speed by allowing the user to efficiently utilize hardware and license resources.

## Lib Test

The Lib Test option in MQA provides a convenient method for quickly checking on model libraries in batch. You can easily find errors in the library file, such as syntax errors, undefined parameters, incorrect links, etc. Lib

Test supports all types of device models and can recognize HSPICE and Spectre libraries automatically.

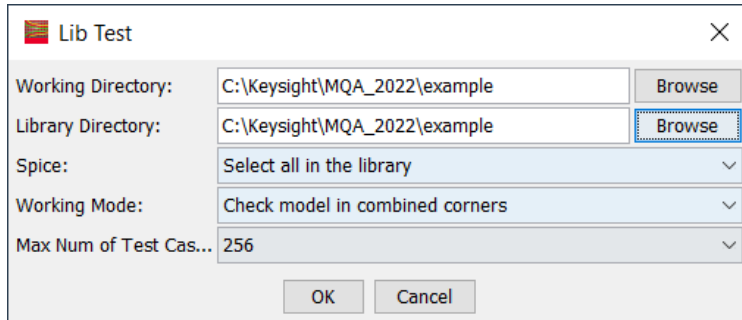


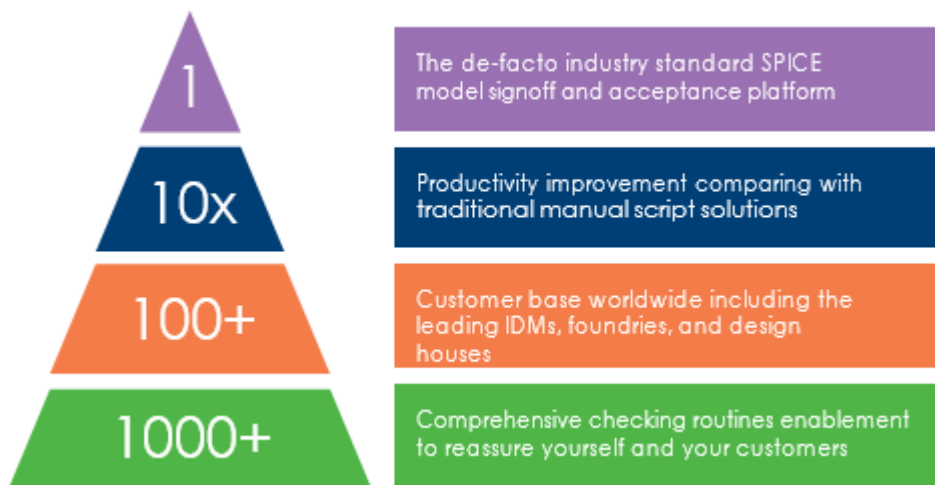
Figure11. Device Modeling MQA plotting function

## MQA's value proposition

Quality guarantee	Productivity improvement	Cost savings
Complete QA flow on one unified platform	Fully automated model QA and documentation	Quickly qualify second source foundries, thereby optimizing manufacturing prices
Comprehensive understanding of model behavior	Quickly bring libraries into compliance	Reduced resources spent on the lengthy and repetitive model QA job and report generation
Avoid costly errors from undetected model imperfections	Rule-driven methodology, ideal for flexibility and team sharing	Save human cost

# Supported Model Formats and Platforms

- Global model, binning model, and macro model
- III-V FETs, HEMTs and HBTs
- MOSFETs (BSIM3v3, BSIM4, BSIM-BULK, BSIMSOI, PSP, HiSIM2, HiSIM\_HV)
- MGFETs (BSIM-CMG and BSIM-IMG)
- Diodes, BJTs (Gummel- Poon, VBIC, HICUM, and Mextram), and passive devices (resistors, capacitors, and inductors)
- Support platforms: Windows and Linux
- Supported simulators include ADS, GoldenGate, HSPICE, Spectre, Eldo, FineSim, SmartSpice, AFS, SPICE3, and the internal engine.



## Product Structure

Device Modeling MQA software provides device modeling engineers with a choice of value-packed, pre-configured combinations of software built for specific device modeling challenges. These combinations enable you to check SPICE model quality thoroughly by automating QA and reporting procedures.

Device Modeling MQA software is based on the W6800B Device Modeling MQA core bundle. The separate Device Modeling MQA elements that provide specific model QA capabilities can be added.

Device Modeling MQA elements comprise one or more separate modules, which add additional model QA functions. These modules, formerly sold separately, are now grouped into efficient and effective combinations.

## Bundles

Model	Name	Description
W6800B	Device Modeling MQA core bundle	Includes Device Modeling MQA core environment
W6347B	Device Modeling MQA/IC-CAP modeling bundle	Includes Device Modeling MQA core environment and Device Modeling IC-CAP core environment, simulation, and analysis module
W6328B	Device Modeling MBP/MQA modeling bundle	Includes Device Modeling MBP core environment and Device Modeling MQA core environment

## Elements

Model	Name	Description
W6511E	Device Modeling MQA bulk CMOS	Model QA packages for PSP, HiSIM2 and BSIMBULK
W6512E	Device Modeling MQA multi-gate FET	Model QA packages for BSIM-CMG and BSIM-IMG
W6513E	Device Modeling MQA BSIMSOI model support	Model QA package for BSIM-SOI
W6514E	Device Modeling MQA HiSIM_HV model support	Model QA package for HiSIM_HV
W6515E	Device Modeling MQA VBIC model support	Model QA package for VBIC
W6516E	Device Modeling MQA viewer	A graphical user interface that enables you to view MQA results and generate reports

# License and Subscription Types

Each Device Modeling MQA module is available in two license versions:

1. A node-locked version allowing the software to execute only on a single PC
2. A network-licensed version for execution on multiple workstations or PCs on a network, allowing various workgroups to share the software. Three types of floating license are available: N - Single site: 1-mile radius from the server; R - Single region 2: Americas, Europe, Asia, and W - Worldwide (export restriction identified in End User License Agreement (EULA))

## World-Class Service and Support

Keysight Design Software is committed to helping you succeed with Device Modeling MQA through customer education courses, technical support, and custom solution services.

To help you begin using MQA quickly and productively, a comprehensive training course is offered at various locations in Keysight facilities or online.

A support contract includes automatic software updates, literature, and documentation to bring you the latest product enhancements and features.

Subscription	Description
KeysightCare support subscription	Perpetual licenses are sold with a 12 (default), 24, 36, or 60-month software support subscription. Support subscriptions can be renewed for a fee after that.
	Subscription licenses already include a software support subscription through the term of the license.

## Web

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