

Keysight Technologies
Model Quality Assurance
(MQA)

Industry Standard SPICE Model
Signoff and Acceptance Platform

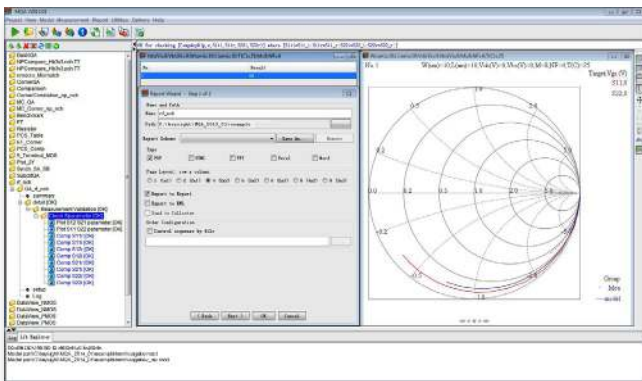


Introduction

Model Quality Assurance (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 deep submicron 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 its comprehensive checking rules while employing easy-to-use interfaces and utilities.

Key Features

- Integrates a comprehensive set of rules to ensure SPICE model quality while overlaying measurements to simulation results
- Fast results and turn-key operations
- Rules and checking functions are flexible and fully customizable; supports Perl and TCL as Scripted-rule
- Quick measurement QA, model comparison and corner model QA
- Powerful plotting functions and utilities
- Open interface enables flexible support of models, simulators and checking routines
- Powerful report generation
- Easy sharing of model information
- Powerful equation viewer
- Model Tweaking function
- Quick check syntax and link in library
- Support of Load Sharing Facility (LSF)
- Complete parallelism support on different levels: simulator level, rule level and project level
- Supports QA projects using different versions of a simulator
- Native support of IC-CAP mdm data and MySQL/SQLite database



The main GUI of MQA

MQA

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

1	2	3
<p>SPICE model validation is becoming increasingly important and significantly more difficult. This is because:</p> <ul style="list-style-type: none"> – As the channel scales down, second-order physical effects make device modeling more complex. – Macro models and binning models have been used extensively. Validating these models is much trickier than global models. <ul style="list-style-type: none"> -- A natural consequence of 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 application can turn out to be a terrible one for other applications. 	<p>Model validation encompasses much more than just overlaying the measurement results to simulation results of the model</p> <ul style="list-style-type: none"> – After all, 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: <ul style="list-style-type: none"> -- 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) -- Capability of the model to predict physical trends (very important in design optimization) -- Model simulation results using benchmark circuits 	<p>Model validation should be automatic and customizable</p> <ul style="list-style-type: none"> – The quality can only be guaranteed after fixed QA procedures are in place. – Manually validating a model is nearly impossible considering the 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

- Are 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 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 own circuits

Calculate point simulation value according to user's specification

Check model accuracy with the measurements

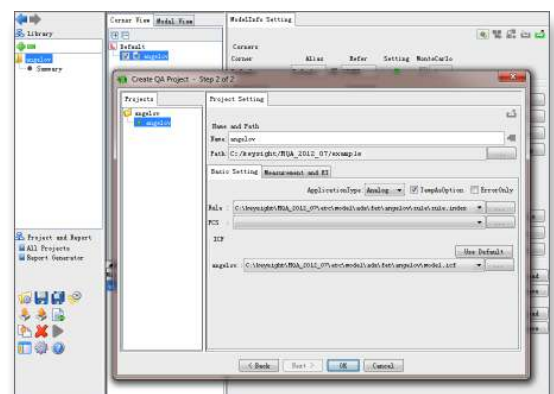
Compare model performance of different models, such as:

- 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 using special routines

- Smith and polar chart plotting
- Check the trend of network parameters
- Load-pull and harmonic balance simulation and plotting
- Thermal noise characterization



Measurement QA

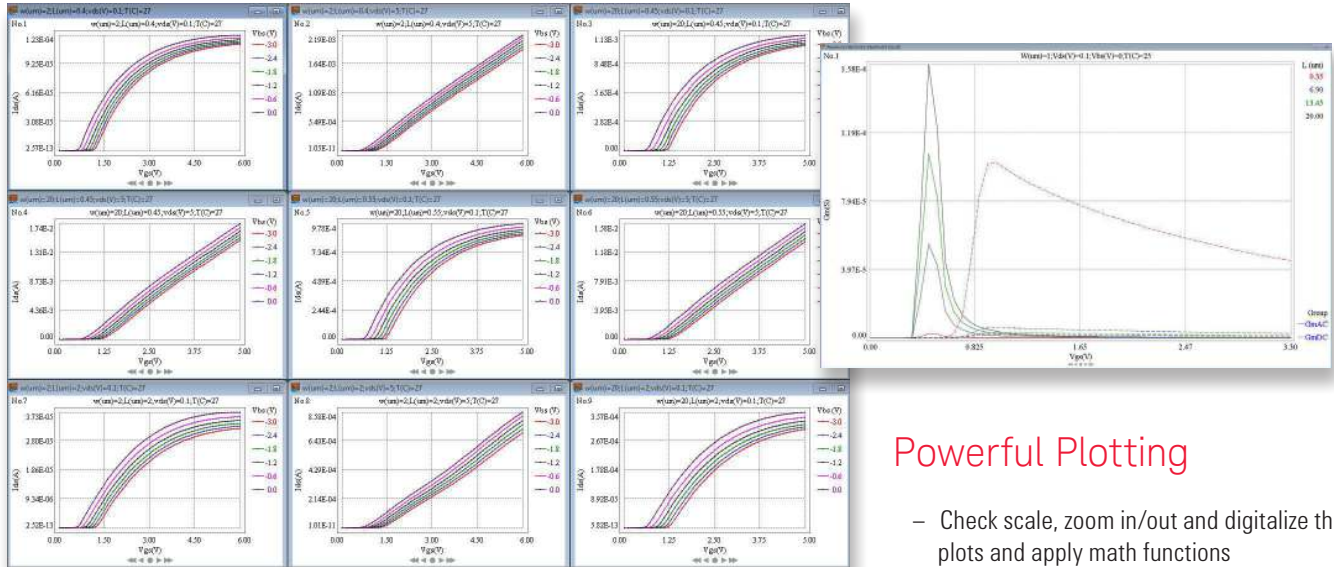
- Quick display of measured device geometry and bias condition
- Plot measured device characteristics
- Check the trend of $I_{dsat} * L$, I_{dsat}/W and V_{th} to detect bad measurements

Customizable Checking Rules

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

Scripted-rule (Perl and TCL), supports

- Cascaded analysis (AC, DC)
- Easily plug in existing user scripts
- Flexible/complex data calculation
- Create user-defined tables freely



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

Powerful Model Reporting

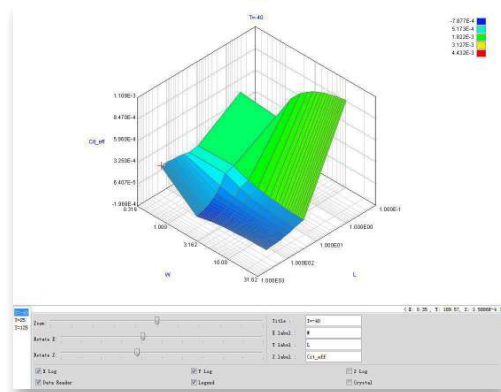
MQA is equipped with a powerful report module:

- 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

Open Interface

MQA provides an open interface for advanced users to utilize their own math functions and data process functions. The open interface can also be used to create a SPICE interface for in-house simulators.

- Implement more math functions with little programming
- Customize/add RMS functions of your preference
- MQA's Java interface has its own engine that enables users to edit, compile and debug their own programs.



Equation Viewer

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

Model Tweaking

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

Lib Explorer

Lib Explorer is an efficient way to clearly present and setup model libraries; all along, making QA work easy and straightforward. 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, reused and accumulated.

Support ET

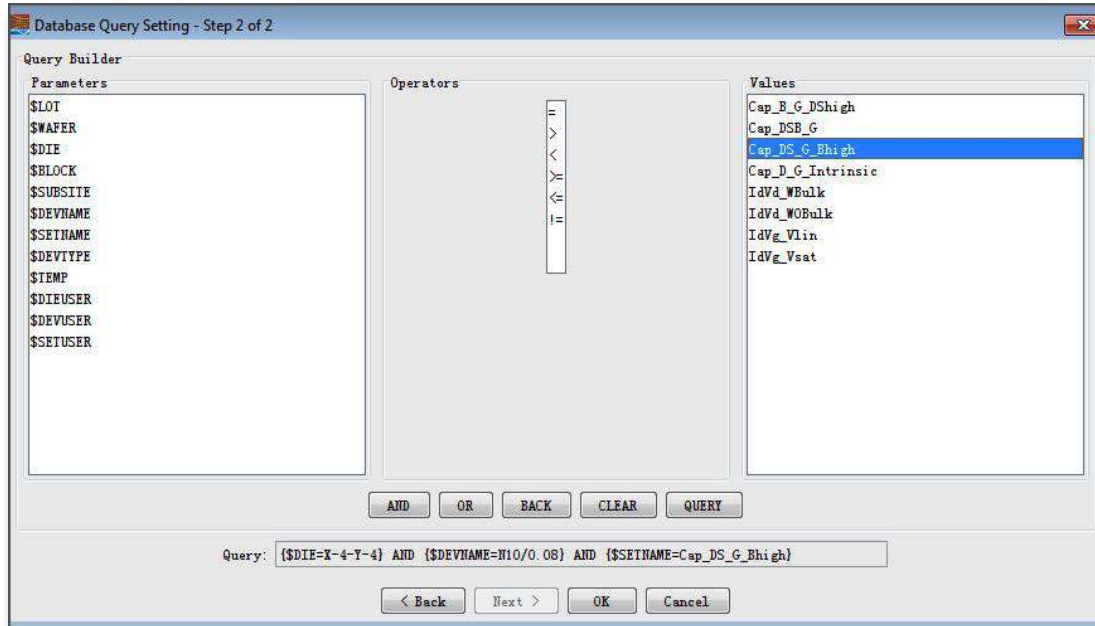
MQA enables you to load ET/PCM data and compare it with your simulation. The ET data can be overlaid with many simulation results in MQA.

Lib Test

The Lib Test option in MQA provides you with a convenient method to do the quick checking on model libraries in batch. You can easily find the 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.

Integrated Data Flow

MQA supports IC-CAP mdm data files and MySQL/SQLite database natively. It enables a seamless data flow across Keysight's device modeling platform.



Speedup by parallelism support on multiple levels

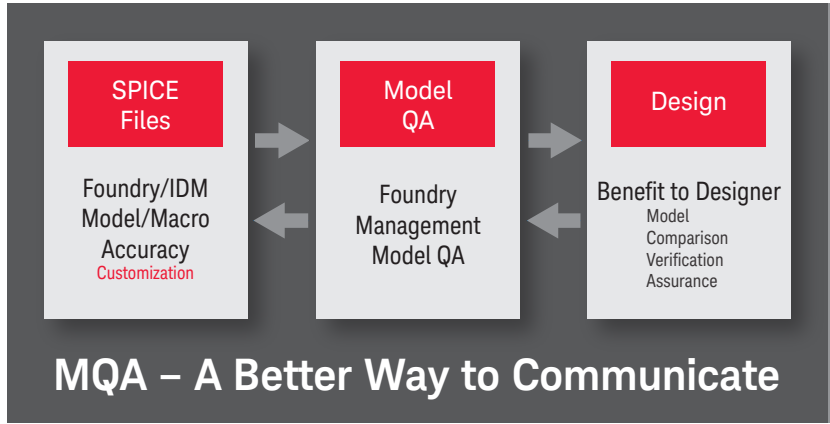
MQA supports LSF and multiple level parallelism including simulator level, rule level and project level. It maximizes the model QA speed by allowing the user to efficiently utilize the hardware and license resources.

Differentiation factors of MQA versus other tools

- MQA is driven by built-in rules established with state of the art modeling expertise.
- The simulation is not limited by a measurement data point, so the validation can check very fine bias steps to validate the quality of the model.
- The built-in check function makes automatic model validation possible.
- Special functions are available to check the binning model and macro model.
- MQA can also check measurements.
- Different benchmark circuits for different design applications.
- Customizable validation criteria for different design applications.
- Special functions to check different process corners.
- Easily add user-specified rules with open user interface.
- MQA enables you to make plots that are not available in other modeling tools.

Supported Model Formats and Platforms

- Global model, binning model, and macro (sub-circuit) model
- III-V FETs, HEMTs and HBTs
- MOSFETs (BSIM3v3, BSIM4, BSIM6, BSIMSOI, PSP, HiSIM2, HiSIM_HV), MGFETs (BSIM-CMG and BSIM-IMG), diodes, BJTs (GP, VBIC, HiCUM, MEXTRAM), and passive devices (resistors, capacitors and inductors)
- Support platforms: Windows and Linux
- Supported simulators includes ADS, GoldenGate, HSPICE, Spectre, Eldo, FineSim, SmartSpice, AFS, SPICE3, etc.



Product Structure

Model Quality Assurance (MQA)

provides the complete solution and framework to fabless design companies, IDMs, and foundries for SPICE model library validation, comparison, and documentation.

Core Environment

The main platform to perform SPICE model validation, comparison and documentation. MQA Core supports the validation of popular models (e.g. BSIM3, BSIM4, BJTs, diodes and

passive devices) and the simulation of mainstream simulators (e.g. ADS, GoldenGate, HSPICE, Spectre, Eldo, FineSim, SmartSpice, AFS, SPICE3, etc.).

- W8644BP/BT Model Quality Assurance Core Environment

Models	Description	Modules
CMOS Model Validation	The products listed below enable BSIMSOI, PSP, HiSIM2, HiSIM_HV, BSIM6, BSIM-CMG, BSIM-IMG model QA with comprehensive built-in rules.	<ul style="list-style-type: none"> - W8632EP/ET MQA BSIMSOI Model Support - W8633EP/ET MQA PSP Model Support Software - W8634EP/ET MQA HiSIM2 Model Support Software - W8635EP/ET MQA HiSIM_HV Model Support Software - W8637EP/ET MQA BSIM6 Model Support Software - W8638EP/ET MQA BSIM-CMG Model Support Software - W8639EP/ET MQA BSIM-IMG Model Support Software
BJT Model Validation	The product listed below enables VBIC model QA with comprehensive built-in rules.	<ul style="list-style-type: none"> - W8636EP/ET MQA VBIC Model Support Software
Script Interface	The products listed below supports TCL & Perl script-based rule files.	<ul style="list-style-type: none"> - W8641EP/ET MQA TCL Support Software - W8642EP/ET MQA Perl Support Software
Viewer Module	The product listed below enables results viewing and report generation of plots and tables generated by MQA.	<ul style="list-style-type: none"> - W8640EP/ET MQA Viewer Site Software

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