IC-CAP Device Modeling Software
Complete and Accurate Parameter Extraction for Semiconductor Device Modeling
About IC-CAP

IC-CAP (Integrated Circuit Characterization and Analysis Program) is the industry standard software for DC, analog and RF semiconductor device characterization and modeling. IC-CAP extracts accurate compact models for use in high speed/digital, analog, power electronics and power RF applications. IC-CAP offers device engineers and designers a state-of-the-art modeling tool that fills numerous modeling needs, including automated instrument control, data acquisition, parameter extraction, graphical analysis, simulation, optimization, and statistical analysis. All of these capabilities are combined in a flexible, automated and intuitive software environment for efficient and accurate extraction of active, passive and user-defined devices and circuits. Today's most advanced semiconductor foundries and Integrated Device Manufacturers (IDMs) rely on IC-CAP for modeling silicon CMOS, Bipolar, compound gallium arsenide (GaAs), gallium nitride (GaN), and many other device technologies.

Features At a Glance

- Open software architecture enables you to achieve maximum accuracy by integrating your own modeling expertise and methodologies, and provides ultimate flexibility to create and automate measurement, extraction and verification procedures.

- Turnkey extraction solutions for industry standard CMOS models, such as BSIM3/BSIM4, PSP, HiSIM, and HiSIM_HV minimize the learning curve and maximize model accuracy.

- Unique nonlinear high-frequency modeling with Keysight DynaFET, NeuroFET, Root models, high frequency BJT, MESFET, PHEMT, and state-of-the-art Verilog-A models.

- Direct links to most commercial simulators (e.g., ADS, HSPICE, Spectre, and ELDO) ensure consistency between extracted models and the simulators used by circuit designers.

- The most advanced and complete on-wafer automated measurement and characterization environment with IC-CAP Wafer Professional (WaferPro).

- Powerful data handling capabilities.

- IC-CAP Power Electronics Model Generator enables the extraction of SiC, GaN and IGBT power devices and works in conjunction with Keysight PD1000A Measurement System for Advanced Modeling.
The semiconductor industry faces continuing challenges to maximize product performance and yield, decrease time-to-market, and reduce production costs. As device geometries get smaller, the need to use accurate models and to control statistical variations in device processing performance becomes even more important. Typical circuit operating frequencies continue to advance well into the RF and microwave frequency range. Accurate device models are critical to circuit simulation convergence and accuracy. Circuit designers need models that can accurately predict device behaviors at DC, as well as in the RF and microwave regions.

Different technologies require a variety of models that can be quickly adapted to their unique processes. Modeling software must therefore, be able to provide modeling engineers with the flexibility to modify and extend model parameters beyond those offered by standard models. To optimize performance and control variations, device designers and process engineers need both accurate models and statistical analysis capabilities. For circuit designers, both capabilities are a requirement for determining nominal performance, as well as extreme or worst-case behaviors.

The amount of data measured for device modeling purposes has been increasing exponentially. With measurements taking several hours or even days, it is important to be as efficient as possible, without compromising measurement accuracy. Measurement control software must work in conjunction with the prober’s native control software, as well as with each instrument, to allow automated measurements across temperature.

IC-CAP addresses these challenges and provides significant competitive advantages to companies within the semiconductor industry.

IC-CAP modeling software offers modular products so that you can choose precisely the modules required for your particular modeling scenario. Central to the IC-CAP platform is the IC-CAP software environment, which supports graphical analysis, programming via parameter extraction language (PEL) and Python, and custom model and user interface development. An analysis module is required in most modeling applications for simulation, optimization and interfacing to external simulators. IC-CAP supports an extensive list of measurement instruments including DC, LCRZ and RF.

The most advanced automated measurement solution

With IC-CAP WaferPro, IC-CAP provides the most advanced solution for device modeling automated measurement. A dedicated test plan environment within the IC-CAP Platform allows the test engineer to measure and post process data using a variety of Keysight and third-party instrumentation.

Accurate Keysight proprietary and industry standard models

IC-CAP contains accurate models for building and maintaining up-to-date model libraries. Within a single environment, you can use IC-CAP to automate measurements, simulate device performance, extract data, optimize model parameters, perform statistical analysis, and generate worst-case models. IC-CAP provides extraction routines for industry standard, as well as Keysight proprietary models for diodes, BJT, MOSFET, MESFET, HEMT, noise, thermal models, and others. Extraction modules offer complete DC to RF parameter extraction capabilities. In addition, IC-CAP supports models and extraction routines that are developed by third parties, as well as numerous other simulation software packages, to accommodate a wide range of customer requirements. IC-CAP also supports the use of Verilog-A models.

Power Electronics (PE) modeling capabilities

Keysight’s Power Electronics Model Generator (PEMG) supports 3 different power electronics device models. These models have been implemented in Verilog-A and are available in ADS. The Si/SiC and IGBT models have been specially formulated for customers who do not have access to device process parameters, a situation that is common in power electronics design labs.

RF and microwave modeling capabilities

Accurate modeling of RF effects requires reliable measurement data. Building on proven strengths in RF and microwave test and measurement, Keysight EESof EDA provides configurations for a variety of RF instruments such as the Keysight PNA, PNA-X and ENA series. IC-CAP RF extraction modules for proprietary and industry-standard models include RF-dependent parameter extraction, ensuring your models are suitable for high-frequency circuit simulation.

The most flexible software environment

IC-CAP operates in an open and flexible software architecture. Although we provide turnkey modeling solutions for many industry standard and proprietary models, most measurement and extraction algorithms can be modified by the user. Using the IC-CAP parameter extraction language (PEL) or the Python programming environment, you can define and add your own models or extraction methodologies directly into IC-CAP. When necessary, the IC-CAP open measurement interface allows you to write your own measurement drivers to control instruments. It is also possible to design custom modeling packages for others to use by implementing custom user interface dialogs with IC-CAP GUI Studio.

Find us at www.keysight.com
Successful device modeling requires accurate measured data and a thorough understanding of the complex integration between the measurement hardware and the modeling software. The IC-CAP software is a powerful modeling tool that can automate industry-standard instruments and systems. Its measurement interface provides turn-key measurement drivers for a variety of single instruments and modeling systems configuration for DC, CV and RF measurements. The measured data is collected and stored in IC-CAP and can be directly used for parameter extractions and optimizations of compact device models. See Table 1 on page 11 for a list of supported instrument drivers.

**IC-CAP WaferPro**

In addition to the comprehensive built-in instrument library, IC-CAP’s WaferPro, provides the ability to drive industry-standard measurement equipment (from bench top instruments to parametric testers), as well as third-party probers, switch matrices and thermal chucks to execute efficient, automated on-wafer measurements across temperature. IC-CAP WaferPro is integrated into the IC-CAP platform and takes advantage of its powerful measurement and programming environment to enable a custom library of efficient measurement routines (e.g., adaptive measurement algorithms) that can greatly reduce the overall measurement time. Since the measurement routines are in the IC-CAP environment, either simple or complex post processing (such as calculation of spot measurements or figures of merit, RF de-embedding and direct extraction), can be applied to measured data before data is saved. Data are saved in either file or SQL Database formats. Swept data are typically saved to IC-CAP MDM file format, while spot measurements are saved to Excel .csv files. To achieve the most efficient data query and import of high volume measured data, data can be saved into SQL Database file. IC-CAP provides a dedicated API to query and import data back into IC-CAP. See Table 2 on page 11 for a list of probers, switching matrixes and thermal chucks supported by WaferPro.

**IC-CAP DataPro**

After collecting and storing data to a file or SQL Database, IC-CAP’s Data Selection and Processing tool (DataPro) allow users to find the “golden” or most typical die for modeling. DataPro applies statistical analysis on measured data and/or on custom key figures of merit (such as gm, ring oscillator freq, etc.) and based on statistical distribution and variances, outliers can be identified and excluded from further analysis. The typical (mean) and corners data are identified and their data can be exported to other tools for target, typical or corner modeling.
When a test routine in the WaferPro Express software is run, the resultant measurement data is organized into a deep hierarchy of subdirectories based on lot name, wafer, temperature, device type, polarity, reticle location and specific measurement parameter groups. In plotting device data from different reticles side-by-side, this hierarchy can be cumbersome to navigate. The data viewer introduced in IC-CAP 2018 automatically navigates the directory structure, finds relevant data and generates plots so you can think about what the data really means. The most common plots are now easily generated, including measurements over bias and statistical data from across the wafer, presented either as a histogram or a wafer map distribution.
Extracting Models with IC-CAP

A typical modeling procedure involves selecting a model based on the device technology and its final circuit application (e.g., DC, high frequency or both), making the necessary measurements to characterize a device or a set of devices, and then finally applying an extraction algorithm to calculate the model parameters. This last step is achieved by either calculating the parameters using built-in or custom model equations from measured data, or by tuning or optimization techniques.

IC-CAP provides the platform and tools engineers need to develop their own extraction methodologies. Turnkey modeling extraction packages for users who need to be up and running by day one are provided by both Keysight and third-party vendors.

The IC-CAP platform provides the following key tools:

- **Advanced Graphical User Interface (GUI)**
  The IC-CAP GUI enables you to create and manage measurement and modeling projects, and read, organize and display data using single or multiple plot window displays. Multiplot windows allow for an unlimited number of plots, easy navigation and zooming capabilities.

- **PEL and Python Programming**
  Measured or simulated data is organized in IC-CAP units called “setups.” Each setup provides the ability to post-process and display data. Data post processing is done real time using PEL or Python. IC-CAP PEL is a simple to learn language that is similar to HP Basic while Python is a modern, object oriented and very powerful language that maximizes speed and productivity.

  These powerful interpreted languages can be used to manipulate data, and create extraction and measurement algorithms within the IC-CAP environment.

  Both PEL and Python allow you to interactively develop new models and extraction routines, and modify existing extraction modules, making IC-CAP an extremely open and flexible working environment.

- **Efficient Data Management**
  The IC-CAP Data Manager allows you to import/export data in an ASCII file format. This format, which has extension .mdm, is now recognized as a standard in the device modeling community and many measurement tools export data into this IC-CAP unique format. Data in other file formats such as .csv, .s2p, and .xls can also be exported and imported.

- **Wide Choice of Industry Standard Simulators**
  Each IC-CAP project can simulate a user-defined netlist, which typically includes the model card and optionally, a subcircuit to be extracted. The IC-CAP simulator engine creates and maintains a Parameter Table based on the model and subcircuit parameters. IC-CAP includes three SPICE simulators and provides direct links to several external simulators (listed in Table 3). The analysis license includes the ability to simulate linear and transient analysis with the powerful Keysight ADS simulator at no extra charge.

- **Powerful Optimizers**
  IC-CAP contains 13 optimization algorithms. Using a combination of different optimization algorithms can be a real advantage when it comes to enhancing the model’s fit. A large number of parameters can be optimized to a large number of weighted data sets. In addition, to automated optimizers and manual tuners, which can be invoked by PEL or Python, a powerful tool called Plot Optimizer makes dynamic interactive optimization easy. The Plot Optimizer is a user interface that enables you to quickly set up all parameter optimization tasks on the fly. You can open the Plot Optimizer from every IC-CAP plot and automatically load the target and simulated data for a quick tuning and optimization.

- **Automation with Macros**
  Tasks within an extraction, or even entire extraction routines, can be automated with macros. A macro is a single programming routine that executes a series of IC-CAP commands, functions, PEL or Python program, or calls to the user environment. With macros, extraction routines developed in R&D can be automated and leveraged to your production areas where minimal user interaction and high productivity are desired.
IC-CAP GUI Studio
The GUI Studio adds powerful capabilities for custom graphical user interface development to the highly flexible IC-CAP software environment. IC-CAP Studio provides users with the ability to directly create UIs tailored and customized for specific contexts and users. An engineer uses IC-CAP Studio to develop a user interface that automates and simplifies an entire measurement or extraction process flow. The customized and optimized UI modeling environment can then be shared and exchanged with other colleagues or outside customers who can easily comprehend the flow and quickly perform the necessary measurement and extraction steps.

CMOS modeling
IC-CAP provides powerful turnkey extraction packages for all CMC industry-standard CMOS models: BSIM3, BSIM4, BSIMSOI, PSP, HiSIM, BSIM-BULK (formerly BSIM6), and HiSIM_HV. The CMOS Extraction packages all share a common architecture, which makes it possible to use the same measured data to extract different CMOS models.

The packages provide the following key features:
- DC, CV and temperature dependent modeling with geometry scaling and binning.
- An easy-to-use user interface makes CMOS modeling easy and convenient.
- Open and flexible extraction methodologies. All packages come with a robust extraction methodology that can be highly customized to adapt to specific process technologies.
- Where fine-tuning and optimization is necessary, the extraction process guides you through predefined optimizer and tuner steps.
- Powerful multiplot data display allows users to create and customize plots, including geometry and temperature scaling plots.
- Automatic generation of complete model documentation in HTML format.
- Automatic failure tracking and reporting during measurement and extraction process.
- Highly accurate RF extraction methodologies with enhanced, scalable RF gate and substrate resistance models.
- Target modeling capabilities. Target modeling allows users to extract a preliminary model based on targets (spot data) or re-center an existing model to match new process specs.
- Corner modeling extraction. Based on process parameters statistical variations and the typical extracted library, this package allows the user to extract corner libraries for a CMOS process. The final library can then be verified for a range of devices, temperatures and bias conditions on all supported simulators.

The CMOS extraction packages are regularly updated to support the latest model versions. Please check the web for updated information on supported versions and simulators.

In addition to the CMC compact models, IC-CAP provides legacy extraction packages for the NXP’s MOS Model 9, UCB level 2, 3 models, and the data-based Root MOS Model. Please see Table 4 for a complete list of CMOS modeling packages and their product numbers.
BJT modeling

BCTM VBIC BJT Model
VBIC is an abbreviation for Vertical Bipolar Inter-Company, a public domain model developed by the Bipolar Circuits and Technology Meeting (BCTM) consortium. It models quasi-saturation, avalanche, and substrate effects. The latest release includes self-heating effects.

High Frequency BJT Modeling Package
This package includes extractions for the Gummel-Poon model, which has been the industry standard model for BJT devices for decades. The package includes a special version of the GP model extraction, which is well suited for RF applications. Here, CV measurements are replaced with S-parameter measurements, making the junction capacitance extraction more convenient and accurate. Improved methods for extracting ideality, base resistance and reverse early voltage are also included. In addition to the standard GP, the package offers extraction for the Keysight EEBJT2 model, a modified GP model to improve the accuracy of both AC and DC behavior.

This Package also includes the extraction of the MEXTRAM CMC Industry standard bipolar model. Its extraction has been implemented in IC-CAP through work jointly carried out by Philips/NXP Research Labs, TU Delft and Keysight EEsof EDA. Extensively used within Philips/NXP, the model has proven to be extremely robust and accurate.

ADS HBT Modeling Package
The Keysight ADS HBT (AHBT) extraction package provides comprehensive measurement and extraction procedures for III-V HBT device modeling. AHBT is a complete HBT model designed specifically for GaAs, SiGe and InP processes, supporting both single and double heterojunctions.

The turn-key package includes comprehensive measurement and extraction procedures.

EEFET3/EEHEMT1 Models
These are empirical, nonlinear models for general GaAs FET or HEMT applications, including large-signal, three-terminal IC and packaged devices. They accurately model DC and bias-dependent S-parameters, time delay, sub-threshold current, and dispersion of Rds. Also included is the drain current model based on Keysight EEsed EDA original equations and advanced models for Cgs and Cgd, including transcapacitance effects. Static self-heating effects in drain current are also taken into account. The modules provide highly automated parameter extraction techniques with package parasitics extracted automatically. HEMTs are similar to MESFETs, but with one distinguishing difference in the behavior of Gm versus Vgs. EEHEMT1 is a superset of EEFET3 and has a set of analytic functions for modeling the Gm compression of a HEMT.

MESFET modeling
The High Frequency MESFET and PHEMT Modeling Package includes extractions for the following models:

Angelov-GaN Model
Modeling Gallium Nitride (GaN) devices is challenging due to the impact of trapping and thermal effects on the device electrical characteristics. Standard GaAs models are not accurate enough for this type of device. The Angelov-GaN model, developed by Prof. I. Angelov at Chalmers University of Technology, has become an industry-standard solution. Keysight's W8S33 IC-CAP Angelov-GaN extraction package provides a dedicated software environment that allows users to perform the necessary measurements and extraction of the Angelov-GaN model. Typical DC and network analyzers are supported for making DC and S-parameters measurements and de-embedding. A convenient user interface lets users execute a step-by-step extraction flow to extract the model parameters. A turn-key flow provided in the package enables complete customization. Simulations are performed using Keysight ADS.

Curtice, Statz MESFET models
The package includes extraction routines for three popular industry-standard MESFET models: the Curtice quadratic, Curtice cubic and Statz (Raytheon). The differences between the three models are in the empirical relationships that describe the DC and AC characteristics of the device. IC-CAP extracts the model parameters from a combination of DC and S-parameter measurements.

Root MESFET/HEMT models
These are process and technology independent, data-based models for large-signal, three-terminal applications. They model nonlinearities of GaAs FETs and HEMTs, including frequency dispersion. These models are scalable for varying geometries and feature automated data acquisition as well as high-speed model generation.

The Root MESFET/HEMT model creator is included in the Root Models generator software license.
Keysight NeuroFET Model

While the Root model was a significant invention for its day, it had some limitations due to the table-based representation of device currents and charges. With the table-based model, non-optimal trade-offs had to be made among modeling all the multi-variate capacitances and conductance over the full bias range of device operation. The NeuroFET model is an evolution of the Root model, with the same topology but with tables replaced by Artificial Neural Networks (ANN). ANNs are a computational paradigm based on how the brain works - they can smoothly approximate any nonlinear function in terms of a network of highly interconnected nonlinear processing functions called neurons. A sophisticated machine learning (AI) training algorithm identifies the weights between nodes to optimally and smoothly approximate the model nonlinear current and charge functions. This is critical for accurately representing distortion behavior, particularly at low signal levels, where high orders of accurate derivatives are required. The NeuroFET model also adds a sophisticated extrapolation methodology beyond the boundaries of the measured data, resulting in robust DC and large-signal simulator convergence behavior. The resultant model is technology independent and works well for both HEMT and FET devices in silicon and III-V materials. It is not designed for passive mixer or switching applications.

Advantages of the NeuroFET over table-based Root models:
- Improved DC and RF convergence
- Improved distortion simulation at low amplitude
- More accurate S-parameters vs. bias

The IC-CAP NeuroFET Extraction package controls DC and S-parameters measurements necessary to extract the model. The ANN training is then accomplished through a specific error optimization procedure. The output model file can then be simulated via ADS within the IC-CAP environment or exported to ADS for use with the built-in NeuroFET circuit simulation component.

Keysight DynaFET Model

The patented Keysight DynaFET model represents another significant innovation in device modeling in that it models dynamic self-heating and trapping effects, to which are attributed important III-V FET dynamic phenomena such as drain lag, current collapse and gate lag. DynaFET uses a novel model identification procedure to identify (extract) trap states and junction temperature directly from large-signal waveform data and derive the detailed coupling of these dynamical variables to the electrical behavior of the device. Like NeuroFET, DynaFET also uses ANNs to describe device charges and currents, but the formulation has been expanded to include device temperature and charge trapping states as additional inputs to the neural networks. A sophisticated machine learning algorithm trains the networks, using DC, S-parameter and large signal waveform measurement data at different ambient temperatures. Nonlinear waveform data are measured with the Keysight Nonlinear Vector Analyzer (NVNA) at a low fundamental frequency (100 MHz) at different temperatures, DC operating points, power levels and load impedances.

The DynaFET model can be applied to high-efficiency power amplifiers, radar applications and low noise amplifiers of GaN and GaAs FETs / HEMTs. It is not designed for switching or passive mixer applications. DynaFET inherits all the advantages of NeuroFET, but adds some key benefits:
- accurate results vs. temperature thanks to dynamic self-heating and temperature dependence.
- Improved broad-band performance versus frequency across the entire device operating range.
- Improved prediction of large-signal nonlinearities (distortion, load-pull, PAE) and long-term memory effects.
- Improved transient performance by independently modeling each dynamic device mechanism and properly coupling them together self-consistently.
- Demonstrated large-signal validation with respect to harmonic tuning at both input and output ports.

A dedicated IC-CAP Add-on controls DC and S-parameters measurements, imports nonlinear measured data from the Keysight NVNA, and extracts the DynaFET ANN for use with ADS. The DynaFET model extraction and training are also available as a service by Keysight.

Third-party models

Open framework

The unique, open and flexible IC-CAP framework enables third-parties to design and develop models and related extraction packages that work as add-ons in the IC-CAP environment. This is possible thanks to the IC-CAP GUI Studio programming environment. The IC-CAP GUI Studio enables third parties to design and implement custom extraction packages, with specific user interfaces and related extraction routines.

BSIMSOI3v2 and EKV 2.6 Extraction Packages are available from ADMOS
www.admos.de

HiCUM and VBIC Extraction Toolkits are available from X-MOD
www.xmodtech.com
The IC-CAP product includes 5 major components:

- IC-CAP Core Environment
- IC-CAP Simulation and Analysis
- IC-CAP Instrument Connectivity
- IC-CAP Wafer Professional (WaferPro)
- IC-CAP Data Processing and selection (DataPro)

IC-CAP is available as a complete Modeling Platform Bundle or as individual modules to give you the flexibility of choosing the exact modeling capabilities you need. In addition to the suite, the IC-CAP WaferPro Measurement Bundle is also available and provides all the capabilities to make on-wafer automated measurements. In addition to these 5 base components, turnkey extraction modules are also available as listed in Table 4.

Keysight W8500 IC-CAP Modeling Platform Bundle

The Keysight W8500 modeling suite provides the basic tools you need to start measuring and modeling devices and circuits. The modeling suite consists of the following components:

- W8501 Core environment
- W8502 Simulation and Analysis
- W8520 Instrument Connectivity

The modeling bundle lets you set up custom extraction routines, measure data using instrument drivers, analyze results, perform simulations, and optimize extracted parameters. Numerous modeling examples are available at no extra cost as a starting points to build and design your own extraction toolkits.

Keysight W8511 IC-CAP Wafer Professional Measurement Bundle

The W8511 provides the ability to run automated DC, CV and RF measurement on-wafer using WaferPro. It includes the following components:

- W8501 Core Environment
- W8520 Instrument Connectivity
- W8510 IC-CAP Wafer Professional (WaferPro)

IC-CAP WaferPro works within, and in conjunction with, the IC-CAP platform and lets users create and execute automated test plans. See the W8510 WaferPro section below for more details. Note that this bundle does not include the W8502 Simulation and Analysis which must be added to run the test plan in simulation mode.

Keysight W8501 IC-CAP Core Environment

The W8501 is the IC-CAP framework. It allows you to perform mathematical transforms, customize plots, write PEL and Python macros, create extraction routines, and write user-defined functions using the C programming language. An extensive function library is included. Also included is IC-CAP Studio, which allows you to develop custom graphical user interfaces.

Keysight W8502 analysis module

The analysis module is the IC-CAP simulator engine that provides the ability to simulate device or circuit performance using the default simulator ADS, the built-in SPICE simulators or by linking to a wide range of other external simulators. The ability to simulate linear (DC, CV and AC) and transient simulation with ADS is included. Links to other (SPICE) simulators can be added using the IC-CAP open simulator interface. Please refer to the web for a complete list of supported simulator links and their versions.

Keysight W8520 Instrument Connectivity

Measurement drivers allow IC-CAP to control and automate the measurement instruments required to characterize your device or circuit. Table 1 lists the wide range of Keysight instruments that are supported with built-in drivers. All C-V, DC, AC, Time Domain and Noise instrument drivers are included in this license.

In addition to turnkey built-in drivers, users can add links to other instruments using the IC-CAP open measurement interface or using PEL or Python to send write/read commands to any instrument connected to the GPIB bus.

Keysight W8503 Data Selection and Processing

IC-CAP Data Selection and Processing tool (DataPro) is a separate toolkit that applies statistical analysis on selected measured data and based on statistical distribution and variances, identifies golden and corner die. DataPro can import data directly from WaferPro (either file-based or database) or from a simple IC-CAP project format. Statistical analysis can be applied to either sweep or spot types of measurements.
### Product Configuration – Measurement Drivers

**Table 1. Supported measurement drivers in IC-CAP W8520 Instrument Connectivity licence.**

<table>
<thead>
<tr>
<th>W8520 Instrument Connectivity Drivers</th>
<th>Instrument supported</th>
</tr>
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</table>
| **LCRZ measurement drivers**          | Keysight E4991A impedance analyzer  
                                      | Keysight E4980A Precision LCR meter  
                                      | Keysight 4194 impedance analyzer  
                                      | Keysight 4271 1 MHz digital capacitance meter  
                                      | Keysight 4275 multi-frequency LCR meter  
                                      | Keysight 4280 2 MHz capacitance meter  
                                      | Keysight 4284 precision LCR meter  
                                      | Keysight 4285 precision LCR meter  
                                      | Keysight 4294A precision LCR meter |
| **DC measurement drivers**            | Keysight B1500A Semiconductor Device Analyzer  
                                      | Keysight B1505A Power Device Analyzer/Curve Tracer  
                                      | Keysight E5270 Series parameter analyzer: E5270B, E5272A, and E5273A  
                                      | Keysight B2900 Series Precision Source/Measure Unit  
                                      | Keysight 4156x semiconductor parameter analyzer  
                                      | Keysight 4140 pA meter/DC voltage source  
                                      | Keysight 4141 DC source/monitor  
                                      | Keysight 4142x modular DC source/monitor  
                                      | Keysight 4145x semiconductor parameter analyzer  
                                      | Keysight 4155x semiconductor parameter analyzer |
| **AC measurement drivers**            | Keysight PNA Series  
                                      | Keysight PNA-X Series (S-parameters, gain compression and intermodulation)  
                                      | Keysight ENA Series  
                                      | Keysight E8356A 10 MHz to 3 GHz  
                                      | Keysight E8357A 10 MHz to 6 GHz  
                                      | Keysight E8358A 10 MHz to 9 GHz  
                                      | Keysight N5250A Millimeter-wave PNA, 10 MHz to 110 GHz  
                                      | Keysight 3577 network analyzer  
                                      | Keysight 8510 network analyzer  
                                      | Keysight 8702 network analyzer  
                                      | Keysight 8719 network analyzer  
                                      | Keysight 8720 network analyzer  
                                      | Keysight 8722 network analyzer  
                                      | Keysight 8753 network analyzer |
| **Time domain measurement drivers**   | Keysight 54121T-54124T digitizing oscilloscopes  
                                      | Keysight 54510 digitizing oscilloscopes  
                                      | Keysight 54750 TDR oscilloscope  
                                      | Keysight 8130 pulse generator  
                                      | Keysight 8131 pulse generator |
| **Noise measurement drivers**         | Keysight 35670A dynamic signal analyzer |

**Table 2a. WaferPro supported Probers**

<table>
<thead>
<tr>
<th>Wafer Probers</th>
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<tbody>
<tr>
<td>Tokyo Electron (TEL)</td>
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<tr>
<td>FormFactor PS21</td>
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<tr>
<td>FormFactor Summit 12K</td>
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<tr>
<td>Suss PA300</td>
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<tr>
<td>Accretech UF3000</td>
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<tr>
<td>Tokyo Electron (TEL) P8 and P12</td>
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<tr>
<td>FormFactor Velox &amp; VeloxPro</td>
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1. Discontinued product.

**Table 2b. Switching Matrix**

<table>
<thead>
<tr>
<th>Switching Matrix</th>
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<tbody>
<tr>
<td>Keystight HP4070 1</td>
<td></td>
</tr>
<tr>
<td>Keithley 707/708</td>
<td></td>
</tr>
<tr>
<td>Keystight HP4080 1</td>
<td></td>
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<tr>
<td>Keystight B2200</td>
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**Table 2c. Thermal Controllers**

<table>
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<tr>
<th>Thermal Controllers</th>
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<tbody>
<tr>
<td>Accretech</td>
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<tr>
<td>Cascade Summit</td>
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<tr>
<td>Cascade PS21</td>
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<tr>
<td>Temptronic TP32A</td>
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<tr>
<td>Tokyo Electron (TEL)</td>
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IC-CAP extraction modules and model generators
The modules listed in Table 4 include all of the measurement setups, mathematical transforms, extraction routines, and documentation required to perform extractions with IC-CAP.

Table 4. Model-specific extraction packages

<table>
<thead>
<tr>
<th>Device Technology</th>
<th>Product Number</th>
<th>Model Extraction Package</th>
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<tbody>
<tr>
<td>CMOS</td>
<td>W8553</td>
<td>UCB BSIM3, Target and Corner Modeling</td>
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<tr>
<td></td>
<td>W8554</td>
<td>UCB BSIM4, Target and Corner Modeling</td>
</tr>
<tr>
<td></td>
<td>W8550</td>
<td>PSP Extraction, Target and Corner Modeling</td>
</tr>
<tr>
<td></td>
<td>W8551</td>
<td>HiSIM2 Extraction, Target and Corner Modeling</td>
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<tr>
<td></td>
<td>W8555</td>
<td>HiSIM_HV Extraction, Target and Corner Modeling</td>
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<td></td>
<td>W8560</td>
<td>HiSIM2 &amp; HiSIM_HV, Target and Corner Modeling</td>
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<td>W8552</td>
<td>UCB BSIMSOI, Target and Corner Modeling</td>
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<td>W8532</td>
<td>Keysight Root MOS</td>
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<td>BJT &amp; HBT</td>
<td>W8541</td>
<td>Keysight HBT</td>
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<td></td>
<td>W8540</td>
<td>High Frequency BJT (EEBJT2) Gummel-Poon &amp; MEXTRAM</td>
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<td>W8542</td>
<td>VBIC</td>
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<tr>
<td>MESFET &amp; HEMT</td>
<td>W8530</td>
<td>Curtice, Cubic Curtice, Quadratic Statz-Pucel (Raytheon) EEFET3, EHEMT1</td>
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<td></td>
<td>W8531</td>
<td>NeuroFET</td>
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<td></td>
<td>W8532</td>
<td>Keysight Root MESFET/HEMT</td>
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<tr>
<td></td>
<td>W8533</td>
<td>Angelov-GaN</td>
</tr>
<tr>
<td>Diode</td>
<td>W8532</td>
<td>Keysight Root diode</td>
</tr>
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Licensed software
Each IC-CAP module is available in two license versions:
1. A node-locked version allowing the software to execute only on a single workstation or a PC.
2. A network-licensed version for execution on multiple workstations or PCs on a network, allowing various workgroups to share the software.

Both licenses use the FLEXlm license management system. These two license options can be mixed freely. For example, a node-locked license of an instrument driver package can reside on a workstation or PC in the lab, while a network license for the analysis module can be shared among a group of engineers for data analysis.
World Wide Web

Our Keysight EEs of EDA World Wide Web includes a special Support Web area for downloadable patches, defects and solutions, and online technical support. In addition, Keysight EEs of EDA gives you access to other services, including:

- News and events
- Product information and on-line demos
- Product applications and examples
- Online product documentation
- Customer training classes
- Online and telephone technical support
- Knowledge center with application examples and users’ discussion forum

World-Class Service, Support and Training

Keysight EEs of EDA is committed to helping you achieve success with IC-CAP through customer education courses, technical support, and custom solution services.

To help you begin using IC-CAP quickly and productively, a comprehensive, three-day training course is offered at various locations, including the Keysight EEs of EDA facility in Santa Rosa, California, USA.

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

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