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DATASHEET

# PrimeLib: Unified Library Characterization and Validation

## Accurate and comprehensive library characterization for successful digital implementation

## Overview

Accurate library characterization is the foundation of successful digital implementation. Synthesis, place-and-route, verification and signoff tools rely on precise model libraries to accurately represent the timing, noise and power performance of digital and memory designs. Cell library characterization complexity has dramatically increased as libraries migrate to more advanced process nodes. Low-power design further complicates the characterization process by introducing complex cells such as multi-bit flip-flops, level shifters and retention logic, which must be accurately characterized to ensure effective digital implementation across multiple power domains. In addition, process variability, aging, reliability and electro-migration on these nodes requires fast and accurate characterization to model and validate the effects. This increased requirements to generate, model and validate data is also responsible for an increased demand on compute for characterization.

## Introduction

The PrimeLib solution includes a comprehensive array of library characterization and QA capabilities that are tuned to produce PrimeTime® signoff quality libraries with maximum throughput on available compute resources. PrimeLib's innovative technologies utilize embedded gold reference SPICE engines to provide a characterization speed up of advanced Liberty™ models used by PrimeTime static timing analysis (STA) to accurately account for effects seen in ultra-low voltage FinFET processes that impact timing. This includes PrimeTime parametric on-chip variation (POCV), advanced waveform propagation (AWP) and electromigration (EM) analysis. PrimeLib is cloud-ready, and with its optimized scaling technology delivers an accelerated throughput on cloud or an on-premise cluster.

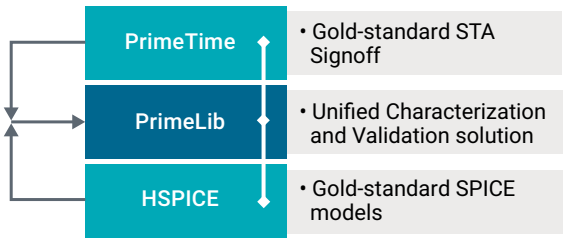


Figure 1: Platform-level integration of PrimeLib with HSPICE and PrimeTime ensures signoff-quality libraries

## Key Features and Benefits

- SmartScaling based multi-PVT characterization to instantly generate libraries and reduce significantly the overall characterization required for multiple PVT corners
- Single captive license bundles everything required for cell library characterization, QA and simulator
- Simple multi-core licensing enables easy adaptation to constantly changing characterization workload requirements
- Embedded gold reference SPICE engines for best accuracy and Integrated signoff library validation tuned to produce PrimeTime sign-off quality libraries
- Innovative technologies provide high characterization throughput
- ML-based high-sigma char w/ HSPICE® AVA
- Faster LVF runtime using new ML models and key technologies
- Cell reliability characterization to capture impacts of device model degradation over time (aging) and electro-migration (EM)
- ML-based augmented sensitivity database to enable faster time-to-market for an updated PDK
- Comprehensive QA features for library validation and SPICE correlation
- Unified GUI for library database management system, job processing, and monitoring, compare and validate libraries—one GUI to visualize it all
- Library characterization environment encryption support enables IP providers to deliver re-characterization kits

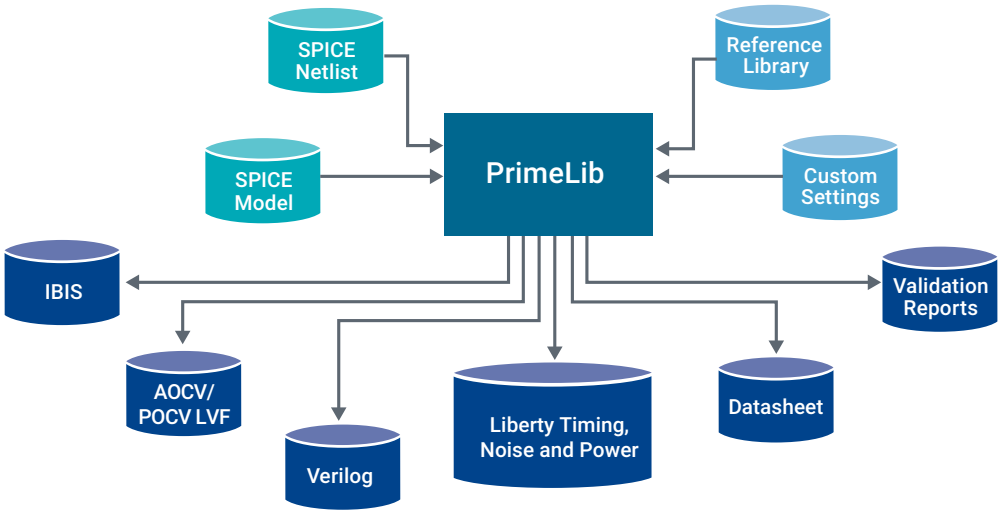


Figure 2: PrimeLib input and outputs

## PrimeLib Statistical Characterization

PrimeLib provides comprehensive solution for fast & accurate process variation characterization and generation of PrimeTime compliant Liberty variation format (LVF), advanced on-chip variation (AOCV), parametric on-chip variation (POCV) models.

PrimeLib offers range of solutions to reduce the overall time for LVF library characterization. Flexible characterization flows are supported to produce accurate libraries. Traditional sensitivity-based approach (SBA) generates accurate LVF data for regular voltage corners where delay/slew/constraint follow a Gaussian distribution. However, at ultra-low voltages, relationship between parameter perturbation and results become non-linear. Variation responses at ultra-low voltage corners display skewed behavior. Machine learning-based algorithms enable accurate modeling of non-Gaussian distribution at ultra-low voltage corners. For golden accuracy reference, PrimeLib provides a Monte Carlo capability which uses the build-in MC feature of the simulator.

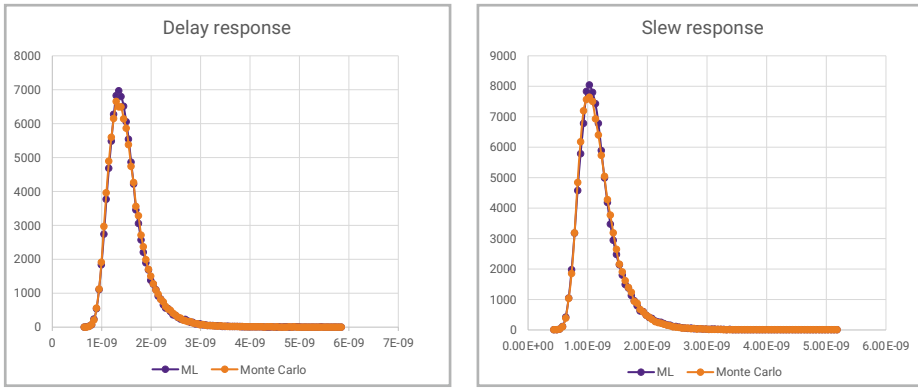


Figure 3: PrimeLib Machine Learning and Monte Carlo response

## Key Features

- Dynamic selection of algorithms (ML/SBA) based on variation trend. The effect of process variation becomes smaller at higher voltages and faster corners. Compute intensive methods (ML) are not necessary at higher voltages. This technology automatically determines whether sensitivity-based approach (SBA) method can be used without compromising accuracy.
- Advanced ML algorithms to produce accurate LVF models for near threshold or sub-Vt corners
- Physical implementation of a single large transistor can be extracted as multiple transistors. This increase in transistor count slows down the computation of the cell sensitivity to process variation. Advanced algorithms are supported to improve LVF characterization turn-around time for cells having fingered devices.
- Pre-analysis flow to filter-out insignificant statistical parameters based on the transistor-level IRV analysis results
- Enhanced algorithm for robust and accurate arc binning
- Delay measurement-based approach instead of bisection approach to speedup LVF constraints characterization runtimes

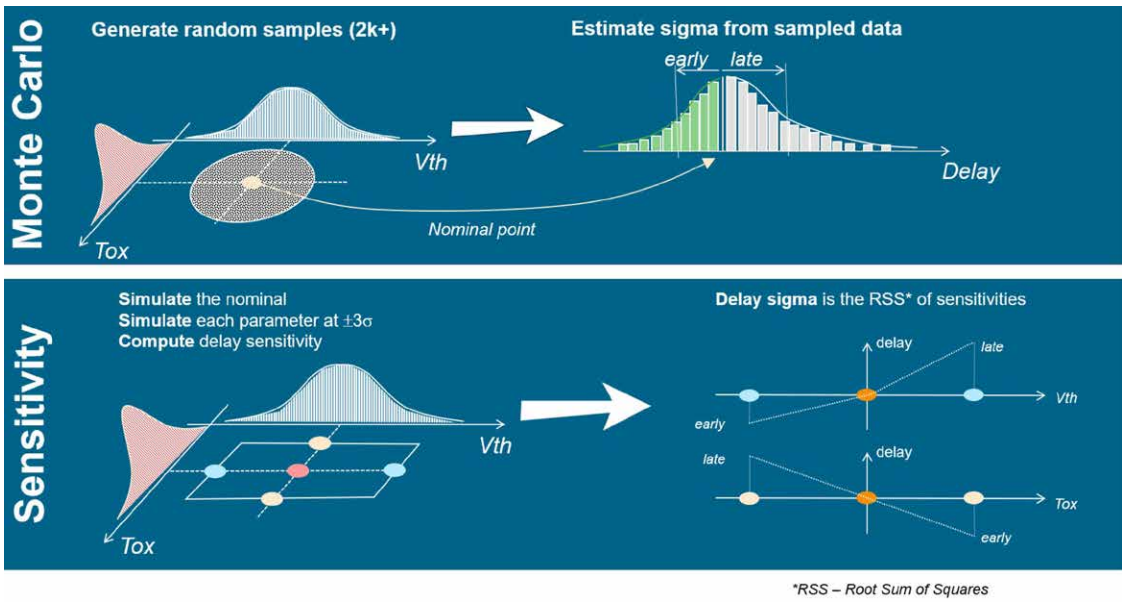


Figure 4: Characterization methods using Monte Carlo and Sensitivity Based Analysis

## High Sigma Characterization

High sigma characterization can be used to ensure robust std cells components at lower process nodes and for automotive applications. PrimeLib tool supports fast and accurate High Sigma Monte Carlo simulation in the 3-5.75 sigma range with HSPICE AVA. Simulators use advanced techniques in ML to reduce the number of simulations by several orders of magnitude compared to traditional MC for high sigma analysis.

## SmartScaling Based Multi-PVT Characterization

SmartScaling for multi PVT characterization reduces the overall requirement to characterize full libraries across different PVTs and significantly improves the overaall turnaround time. SmartScaling solution produces instant zero-cost intermediate libraries using SmartScaling database at selected corners based on anchor PVTs. Multi-Dimensional scaling (across voltage, process & temperature) feature uses the SmartScaling engine to generate accurate signoff quality libraries with timing/CCST/CCSN/ power/LVF data.

## PrimeTime Signoff Quality Libraries

Advanced process node standard cell libraries require accurate timing and noise models to ensure confident static timing analysis signoff—especially for mobile IC and IoT applications operating at ultra-low voltages. To meet the accuracy needs for advanced node characterization, PrimeLib model generation has been tightly calibrated with PrimeTime and HSPICE® models to provide the best correlation and accuracy results.

## Integrated Signoff Library Validation

Successful IC design requires high-quality libraries. PrimeLib provides a comprehensive set of capabilities for quality assurance to verify the consistency, accuracy and completeness of the libraries. These capabilities include consistency checks across views within a library with easy to visualize HTML reports and heat maps, GUI-based library-to-library comparison capabilities, as well as advanced SPICE based correlation capabilities for timing, noise, constraints and power.

## Simple Multi-Core Licensing

PrimeLib's unique licensing approach easily adjusts to varying workload profiles thereby eliminating the burden on characterization teams to predict future workload requirements and having to operate within the constraints associated with traditionally cumbersome licensing methods. Dedicated SPICE availability for characterization teams is another added benefit.

## High Characterization Throughput: Optimized for Cloud or Cluster

PrimeLib provides high throughput on a wide range of computing environments with its many performance-focused features. This includes netlist optimization, automatic function recognition with vector generation, vector optimization and efficient utilization of compute resources on cloud or in cluster. Library characterization is a disk-intensive and highly distributed process. PrimeLib is optimized for NFS traffic and disk usage and scales linearly to provide fastest and efficient throughput based on available resources. PrimeLib's enhanced license checkout mechanism reduces the overhead on license servers that can be caused by highly distributed processes.

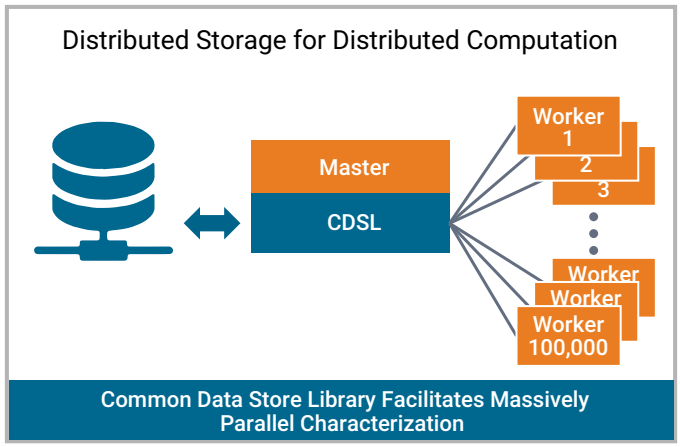


Figure 5: Parallel Characterization

## Cell Reliability Characterization

Advances in process technology are increasing the impact of Electro-Migration (EM) on the performance and reliability of designs. Similarly, the stress and degradation in the performance of transistors with continued usage over a period of time is another growing reliability concern.

Hence, cell reliability characterization is an important capability that PrimeLib has to offer given the pressing need of long running applications such as the automotive industry.

EM characterization in PrimeLib is supported for avg, rms and peak current types. Aging characterization is supported for MOSRA, TMI and OMI aging models for both BTI and HCI effects. Both these characterization flows are based on the basic characterization flow making them easy to setup and use.

## Library Characterization Environment Encryption Support

IP providers have to deliver re-characterization kits to their customers, without opening up their characterization methodology IP. This is where the library characterization environment encryption support of PrimeLib is useful.

## Simulator Support

PrimeLib offers support for our existing FineSim and HSPICE simulators as well as for the next generation PrimeSim simulator products.

The embedded as well as the standalone simulator invocations are captive in nature—so you don't have to worry about checking out any additional simulator license keys. The PrimeLib-Core license tokens are all you need to invoke any of these simulators.