

# Property Synthesis Throughout the Design Flow for Application in Formal Verification, Simulation, and Emulation

This white paper describes the Cadence® JasperGold® Property Synthesis Apps, members of a family of interoperable, application-specific formal verification solutions that addresses verification challenges throughout the design flow [1, 2]. These Apps, the JasperGold Behavioral Property Synthesis (BPS) App and the JasperGold Structural Property Synthesis (SPS) App, synthesize both behavioral and structural properties—also known as assertions—for use in formal verification, simulation, and emulation. They significantly increase verification coverage while simultaneously boosting property generation productivity by more than an order of magnitude.

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## Introduction

The value of using behavioral and structural properties in all three verification/validation domains—formal analysis, simulation, and emulation—is well established. For example:

- Behavioral properties verify the design intent of an RTL block by analyzing its black-box behavior, that is, the end-to-end, multi-cycle signal behavior at the block boundary. Such “concurrent” properties can verify the correct behavior of, for example, a block interface when implementing a complex handshake protocol. Behavioral properties applied to such scenarios not only increase functional coverage, they can also eliminate the need for long simulation runs.
- Structural properties verify implementation intent by analyzing the block’s internal signals—a white-box approach. Such “immediate” properties verify, for example, the correct behavior of basic storage and logic functions such as FIFOs and FSMs.

However, design teams are faced with two questions: How many properties are enough and where should they be inserted for maximum effect? Some experts suggest property density as a practical metric, and recommend one property per 10 to 100 lines of RTL code as an appropriate density [3]. However, it takes several hours to write, verify, and debug even a relatively simple property. Consequently, achieving the recommended property density even on a modestly sized RTL block can require several engineer-weeks of effort. All too often, the design team has insufficient time and resources to complete the task, so property writing is curtailed—and so is the value of using properties.

Clearly, design teams need an automated property-generation solution—one that generates and inserts the “right” properties in the “right” places.

## Property Synthesis Selection Criteria

Property synthesis tools address this synthesis challenge with varying degrees of sophistication. The most important selection criteria, as identified by customers, are:

- The tool must synthesize properties that can be deployed in the user's verification/validation domains of choice—formal verification, simulation, and emulation. Being restricted to one or two domains might exclude use of the tool.
- The tool must synthesize structural properties directly from RTL. Having to create a throwaway testbench to supply additional data to the tool is undesirable, especially in the early stages of design.
- The tool must synthesize behavioral properties purely from black-box data.
- Users don't want to have to provide white-box data or to extensively intervene manually to generate behavioral properties.
- The tool must use the multi-cycle analysis necessary to synthesize and analyze behavioral assertions and to find simulation-based functional coverage holes.
- The tool must exercise the intelligent monitoring and control necessary to reduce the number of property candidates for post-synthesis manual review.

## JasperGold Property Synthesis Apps

The JasperGold Property Synthesis Apps are comprehensive, automated solutions that meet these criteria. They are used throughout the design cycle from early RTL validation, through formal verification convergence and verification closure. They automatically generate both behavioral and structural properties in ready-to-use SystemVerilog Assertions (SVA), relieving the design team of an otherwise time-consuming manual task.

- **The Behavioral Property Synthesis (BPS) App** accelerates verification closure by extracting properties from simulation information—with or without knowledge of the RTL code—to find coverage holes, to increase functional coverage, and to raise the overall property density. Its multi-cycle analysis enables accurate temporal property analysis and comprehensive coverage. In addition, properties can be extracted from signals from different modules across different levels of hierarchy to analyze and verify signal relationships.
- **The Structural Property Synthesis (SPS) App** eliminates common functional design errors before functional verification commences. It extracts structural properties directly from the RTL semantics without the need to create a throwaway testbench. The structural properties can be configured from a wide variety of checks such as dead code checks, FSM checks, and arithmetic overflow checks.

## Unique Characteristics

The JasperGold Property Synthesis Apps have a number of unique characteristics that differentiate them from other assertion synthesis tools, in addition to characteristics commonly found in such tools.

### Comprehensive Property Synthesis

- Both Apps synthesize properties for use in all three verification/validation domains—formal verification, simulation and emulation—in contrast to tools that support only one or two domains.
- Both Apps synthesize both structural and behavioral properties, in contrast to tools that synthesize only one or the other.
- The JasperGold BPS App synthesizes behavioral properties from black-box data without the need for white-box data, in contrast to other tools that require the design team to provide such implementation data and to perform a detailed, manual post-synthesis review of properties.
- The JasperGold SPS App synthesizes structural properties directly from only the RTL code, eliminating the need to create a throwaway testbench as required by many other tools.

### Advanced JasperGold BPS Analyses

The JasperGold BPS App:

- Pre-ranks properties according to validation value—the right properties—and performs functional ranking to target properties effectively—the right places.

- Uses multi-cycle analysis to identify simulation-based functional coverage holes, in contrast to other tools, none of which support multi-cycle analysis.
- Reduces the number of properties that the design team must review by (a) merging simpler properties into more complex properties and (b) identifying and rejecting synthesized properties that duplicate embedded properties, in contrast to tools that oblige users to manually apply this “verification intelligence.”
- Leverages user-provided critical expressions to synthesize and insert properties in locations of particular interest.

### Diverse Properties, Constraints, and Design Languages

Both Apps:

- Export the three primary property types—assertions, covers and assumptions—in ready-to-use SVA.
- Extract block-level constraints from simulation for use in formal property verification.
- Support VHDL, in contrast to tools that support only Verilog and SystemVerilog.

### Flexible Use Model

Both Apps:

- Run batch-mode analysis of simulation data provided by an existing fast signal database (FSDB) or value change dump (VCD) file, eliminating the need to activate one or more simulation licenses.
- Analyze simulation data in real time via the simulator’s PLI link.

In addition, the JasperGold Apps’ flexible licensing model enables design teams to optimize license usage and budget by, for example, processing several instances of the App in parallel on different functional blocks.

### Summary

The Cadence JasperGold Property Synthesis Apps, the JasperGold BPS App and the JasperGold SPS App, offer comprehensive property synthesis, advanced behavioral property synthesis analyses, diverse property and language support, and a flexible use model. With these features, the two Apps give design teams a versatile and cost-effective means to significantly increase verification coverage while simultaneously boosting productivity by more than an order of magnitude. The JasperGold Property Synthesis Apps generate the “right” properties in the “right” places.

### References and Further Information

1. [Interoperable Application-Specific Solutions for Formal Verification Throughout the Design Flow](#). Cadence white paper. June 2015.
2. [We need a simpler and faster approach to formal verification!](#) by Rajeev Ranjan. EE Times, 30 July 2012.
3. [Assertion-Based Design](#) by Harry D. Foster, Adam C. Krolnik, David J. Lacey. Second Edition. Springer Verlag. 2004

To learn more about Cadence JasperGold Apps, contact your local sales office at [http://www.cadence.com/cadence/contact\\_us](http://www.cadence.com/cadence/contact_us).



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