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Innovations

BiCMOS 5HPE Models for Design and Simulation

Models are designed to represent elements as they will be in an actual fabrication; parasitic capacitance, noise model representation, process variance, matching variance, and similar items are included in the model. When a designer changes the size of a circuit element, the model is designed to reflect these changes, which helps achieve a more rapid path to a successful design.

All BiCMOS 5HPE models are physical-based scalable compact models that provide designers with great flexibility and accuracy over a wide range of applications. The models are based on electrical measurements of nominal hardware using DC and capacitance-voltage (CV) characterization (over voltage and temperature), AC characterization (S-parameters), noise characterization, and characterization of bridge structures and current mirrors for device matching. The CMOS models are the latest BSIM3 version 3.2 models which include accurate subthreshold characteristics and also incorporate models of the thermal and 1/f noise. Bipolar transistor models are developed using the Cadence Spectre VBIC models, which provide superior correlation to hardware in quasi-saturation than the more traditional Spectre Gummel-Poon model. All passive elements are represented with parasitics, thermal variance, and process variance.

The models incorporate the realistic statistics of process variations by correlation of process-split hardware measurements to key model parameters. The models support Monte Carlo simulations with local mismatch as well as process (3-sigma) corner analysis capability. All the device simulations are run with state-of-the-art design environments (Cadence Analog Artist and Agilent's ADS). Because the models are derived from empirical data, they closely reflect the device performance obtained on manufactured hardware.

BiCMOS 5HPE's Applicability to RF/Wireless Designs

The broad use of RF, analog, and mixed-signal techniques in the wireless application space precludes a simple description of how a technology will be used. From a very coarse viewpoint, designers will attempt to integrate voltage-controlled oscillators (VCOs), phase-locked loops (PLLs), mixers, synthesizers, digital-to-analog converters (DACs), and analog-to-digital converters (ADCs) into single-chip modules. Given that 5HPE is weighted towards higher performance analog/RF features, it will best serve as a technology for front-end processing of RF and IF signals, as summarized in Table 3.

The following examples are meant to distinguish 5HPE from the BiCMOS technologies that are typically available today and to demonstrate the unique coupling of this set of features.

- The ability to stack the MOS, poly-poly, and BEOL MIM capacitors results in exceptionally area-efficient high-density capacitors. Stacking also reduces parasitic effects from the substrate, which makes 5HPE advantageous for synthesizers, bias control circuits, and applications such as on-chip filters requiring the use of multiple capacitors.

Table 3. BiCMOS 5HPE Wireless Applications

SiGe 5HPE Applications		
Application	**Components / Functions**	
	RF	**IF**
Bluetooth	LNA, VCO downconverter, upconverter	Integrated BPFs, ADC, DAC, demod, bit-slicer
1-way pager	LNA, VCO, downconverter	ADC, IF demod, bit-slicer
2-way pager	LNA, VCO*, PLL I/Q downconverter, I/Q upconverter, PA driver	ADC, IF demod, IF mod, DAC, bit-slicer
WLAN	LNA, VCO*, PLL, downconverter, upconverter, PA driver	Rx amp, VCO*, PLL, I/Q demod, BPF Tx amp, I/Q mod
Cordless handsets	LNA, VCO*, PLL, downconverter, upconverter, PA driver	Rx amps, VCO*, PLL, I/Q demod, Tx amp, I/Q mod
Digital wireless handsets	LNA, PA driver, downconverter, upconverter	Rx amps, VCO*, PLL, I/Q demod, Tx amp, I/Q mod
GPS receiver	LNA, AGC amp, oscillator, LPF	3-level quantizer, temp sensor, integrator
Set-top box / digital TV	LNA, downconverter	Rx amps, VCO*, PLL, I/Q demod

* With optional AM metal added.

- High breakdown-voltage HBTs and FETs make it easy to design 3-V to 5-V circuits. For example, circuit topologies that necessitate the use of vertically stacked NPNs are possible with the high breakdown voltage NPN. This increases the number of potential circuit solutions available to the designer. The higher breakdown-voltage devices can also be applied to areas of a design that experience significant signal level swings.
- The availability of a lateral PNP opens up the possibility of lower noise and improved device matching in addition to aiding designs requiring complementary bipolars; e.g., current mirrors, low-noise current source, and circuits referenced to the positive power supply.
- An isolated NFET can be biased to eliminate the body effect. Biasing the NFET well above or below ground introduces design flexibility.
- Thick analog metal results in high Q inductors which can be used as the resonating elements in integrated VCOs. At RF frequencies, the thick metal also allows for lower loss on-chip impedance matching.

- Although the focus is on wireless applications, the high-speed data wired application space (SONET) would see utility in the ability to design circuits requiring 3.6 V.

Summary

The consumer-led demand for wireless products is driving the wireless industry's requirements for lower-cost technology, reduced cycle time, enhanced device performance, and high integration level. BiCMOS 5HPE excels in meeting these requirements and presents a new complementary offering to the existing family of IBM SiGe technologies.

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Natalie Feilchenfeld is a technical team leader working in the IBM SiGe technology development group in Essex Junction, VT. She and her team are responsible for the qualification of the BiCMOS 5HPE technology.

Steven Astravas is an IBM strategic marketing representative in the wireless business line marketing group at the Boston Design Center in Lowell, MA. He is responsible for wireless communication products and applications.

Matt Gallagher is a technology development team leader working in the wireless products business unit in Essex Junction, VT. He is leading a team to define the semiconductor technologies that will be required for IBM to succeed in the wireless marketplace.

Sam Gibson is an IBM senior engineer/scientist in the RFIC development group at the Boston Design Center in Lowell, MA. His interests include RF IC design, and he works closely with the wireless products and SiGe technology development groups.

Jerry Twomey is an IBM RF/analog designer working at the Encinitas Design Center in Encinitas, CA. He is an instructor in analog and mixed signal IC design at UCSD-Extension and has authored papers for EDN and electronic design magazines.