

# 0.8 $\mu\text{m}$ CMOS Process

## > CX08

### 0.8 Micron Modular Mixed Signal Technology

#### > Description

The CX08 Series is X-FAB's 0.8 Micron Modular Mixed Signal Technology. Main target applications are standard cell, semi-custom and full custom designs for Industrial, Telecommunication and Automotive products - including the 42V board net.

Based on a state of the art single poly double metal 0.8-micron drawn gate length N-well process for digital application, various process modules are available for high performance analogue and high voltage circuits.

Reliable design rules, precise SPICE models, analogue and digital libraries, IP's and development kits support the process for major CAE vendors.

#### > Key Features

- 0.8-micron single poly, double metal N-well core process with 11 masks
- Double poly module for poly-poly capacitors (one additional mask)
- High-resistive poly resistor module (one additional mask)
- High-voltage option up to 50V DC for HV NMOS, PMOS, DMOS, JFET and bipolar devices (four additional masks) with advanced EMC and latch-up immunity and reduced substrate noise due to triple well concept
- Extended high-voltage module - NMOS, PMOS, DMOS for 42V board net automotive application
- EEPROM module for NV-latches
- Power-metal option (third metal) for smart power applications (two additional masks)
- Large number of primitive elements
- High precision BSIM3V3 SPICE models
- Excellent analogue performance with accurate device matching
- Various digital core cell libraries optimised for most typical applications
- 1200 to 1500 effective gates per  $\text{mm}^2$
- Typical gate delays (digital) of 160 ps
- 5V and 3.3V I/O cell libraries
- IEEE 1149.1 boundary scan macros
- Electrostatic discharge (ESD) protection in accordance with MIL-STD
- Analogue library
- High-density RAM, DPRAM. ROM blocks
- OTP options: poly-fuses, zener-zaps
- Development kits for major EDA tools
- Megafunctions and IP's available

#### > Applications

- Mixed signal embedded systems; systems on a chip (SOC)
- High precision mixed signal circuits
- Low-power mixed signal circuits
- Analogue frontends for sensors
- Circuits with integrated high voltage I/O's and voltage regulators
- Instrumentation
- AD/DA Converters
- Communications, automotive and industrial markets

#### > Quality Assurance

X-FAB spends every possible effort to improve the product quality and reliability and to provide competent support to the customers. This is maintained by the direct and flexible customer interface, the reliable manufacturing process and complex test and evaluation conceptions, all of

them guided by rigorous quality improvement procedures developed by X-FAB. This comprehensive, proprietary quality improvement system has been certified to fulfill the requirements of the ISO 9001, QS 9000, VDA 6, ISO TS 16 949 and other standards.

#### > Deliverables

- PCM tested wafers
- Optional production services: wafer sort, assembly and final test
- Optional Engineering services: Multi Project Wafer (MPW) and Multi Layer Service (MLM)
- Optional Design services; e.g. feasibility studies, place & route, synthesis, custom block development
- Second source available

> Digital Libraries

- Foundry-specific optimized libraries
- Standard core library for high speed digital blocks
- Low-power library, 50% less power, 40% less area
- Isolated library for reduced substrate noise and improved EMC
- IEEE 1365 Verilog simulation models
- IEEE 1076.4 VHDL-VITAL simulation models
- Synthesis libraries
- IDDQ libraries
- Macrofunction and IP's on request
- RAM, DPRAM, ROM
- Poly fuses, Zener zaps
- NV latches

> Analog Libraries

Primitive Devices	Analogue Macrocells	Analogue Megafunctions
NMOS/PMOS Transistors	Operational Amplifiers	Digital to Analogue Converters
HV NMOS/PMOS Transistors	Comparators	Analogue to Digital Converters
DMOS Transistors	Bandgap-Reference and Bias Voltage Generators	Power Supply (Voltage Regulator)
JFET's	Crystal Oscillators	Phase Locked Loop
NPN/PNP Bipolar Transistors	RC Oscillators	
Diodes	Analogue Switches	
Capacitors	Analogue Inputs and Outputs	
Poly silicon and Diffusion Resistors	LCD Drivers	

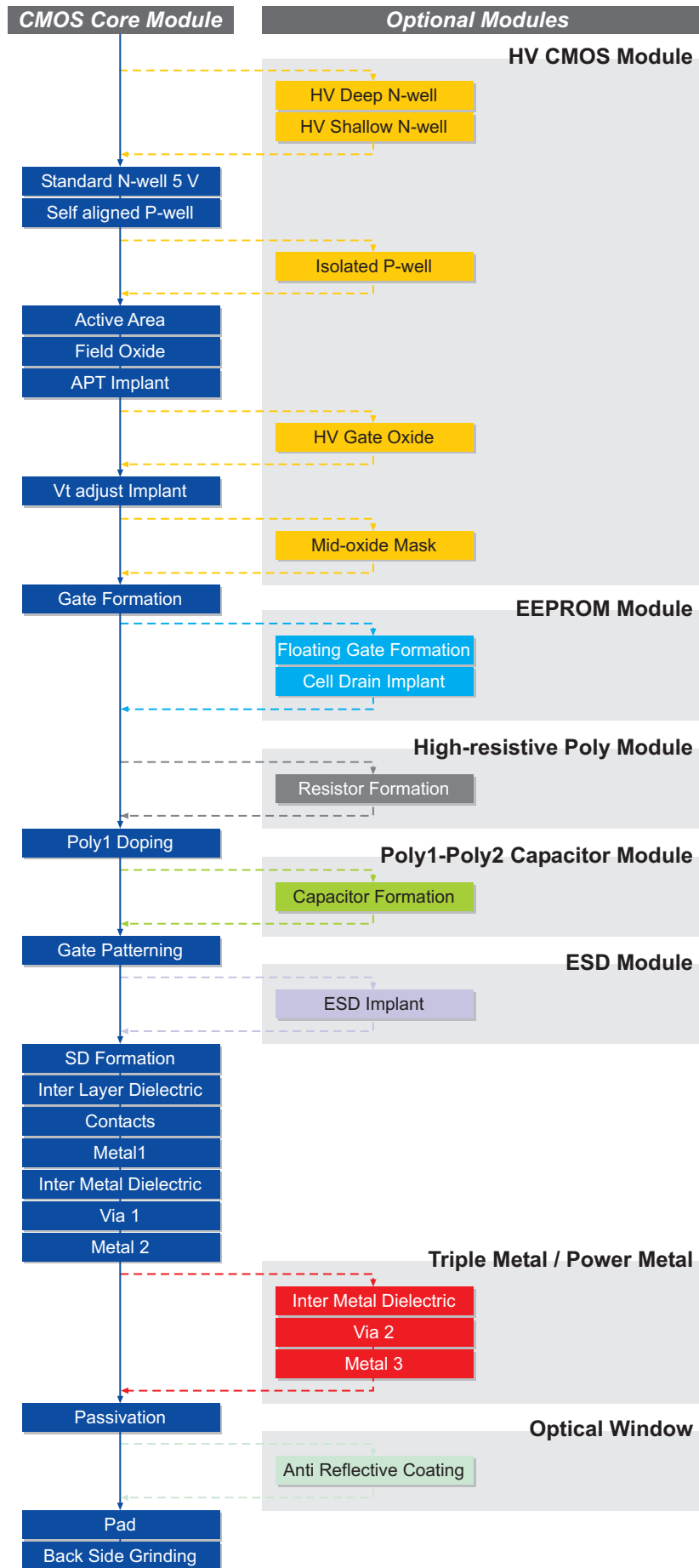
> Process Options

Module Name	No. of Add. Masks	Remarks	Typical Primitive Devices Applications
CMOS core	11	single poly double metal CMOS	5V NMOS/PMOS bipolars, resistors

The core module can be combined with one or more of the following additional modules:

Module Name	No. of Add. Masks	Remarks	Typical Primitive Devices Applications
high voltage CMOS	4	triple well (isolated p-well) dual gate oxide	HV NMOS/PMOS additional bipolars, diodes
extended high voltage CMOS	-	optimized technology for improved mid-oxide high voltage transistors	80V HV NMOS/PMOS 42V automotive board net
EEPROM	2	double poly, patented nonvolatile memory cell	NV Latches double poly capacitor
poly1-poly2 capacitor	1	double poly, alternatively for EEPROM module	double poly capacitor analog
high resistive poly	1	selectively doped single poly	high ohmic resistor analog
ESD implant	1	ESD implant	5V ESD-NMOS 5V-I/Os with ESD robustness up to 8kV
triple metal	2	additional metal layer	more complex wiring
power metal	2	thick third metal, alternatively for triple metal module	reduced internal resistance, higher currents
optical window	1	oxide window	optical applications

> Main Process Flow



> Schematic Cross Sections

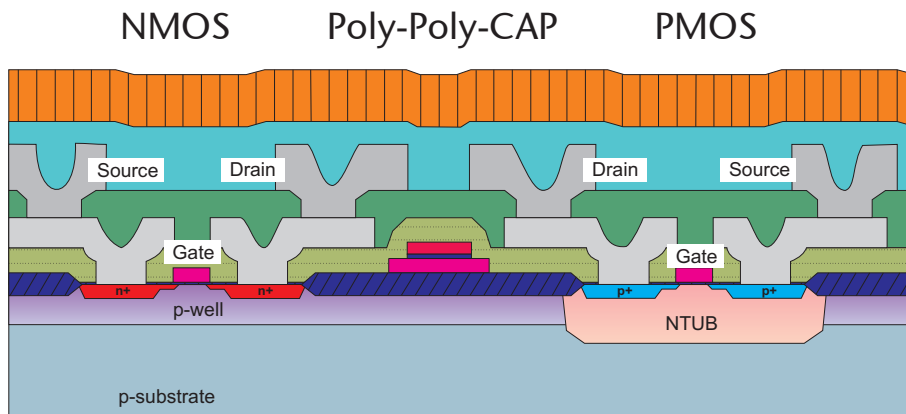


Figure 1: 5V devices

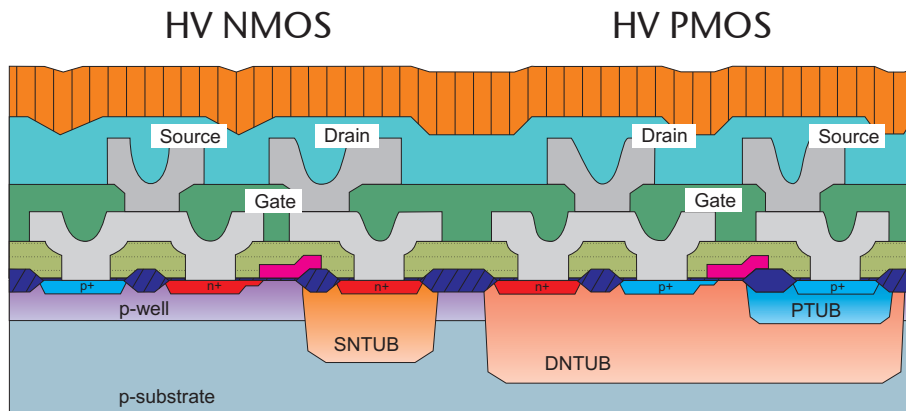


Figure 2: High Voltage devices with power metal

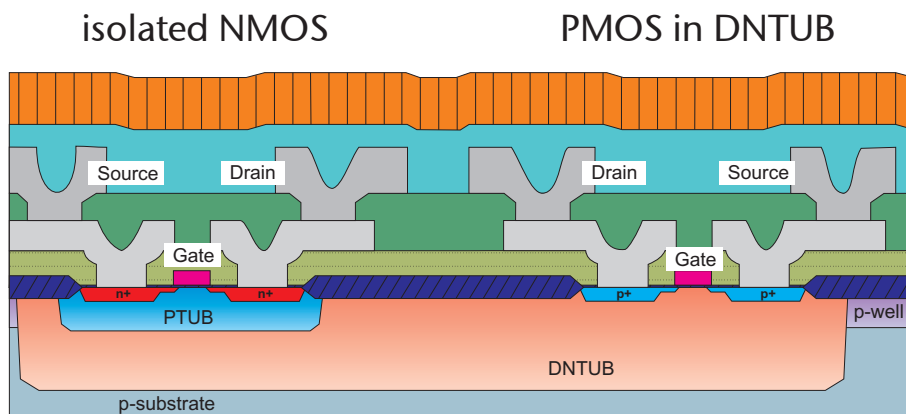


Figure 3: Isolated 5V devices

Basic Design Rules		
Mask	Width [ $\mu\text{m}$ ]	Spacing [ $\mu\text{m}$ ]
Standard N-well	5.0	5.0
HV deep N-well	5.0	11.0
HV shallow N-well	5.0	7.0
Isolated P-well	3.0	5.4
Active Area	0.8	1.4
Poly-Silicon Gate	0.8	0.9
Contact	0.8	0.8
Metal 1	1.1	1.0
Via 1	0.9	1.0
Metal 2 / Metal 3	1.2	1.1
Via 2	1.6	1.6
Metal 3 (Power Metal)	3.0	3.0

> Device Parameters

The following devices can be used for circuit designs. They are well characterised and part of a primitive device library. The device names correspond with the SPICE model names. They all have been qualified.

Different reliability tests gave the maximum allowed operating conditions; the values in brackets denote absolute maximum ratings. See also the availability with different options.

**Active Devices** (typical data)

MOS Transistors							
	Device Name	available only with	VT [V]	IDS [ $\mu\text{A}/\mu\text{m}$ ]	BVDSS [V]	Max. VDS [V]	Max. VGB [V]
NMOS 5V	NMOS4		0.72	380	13	5.5	5.5
PMOS 5V	PMOS4		-0.80	185	-12	5.5	5.5
Isolated NMOS	NMOSPW	HV	0.68	380	13	5.5	5.5
PMOS in HV Well	PMOSNWD	HV	-0.80	185	-12	5.5	5.5
High Voltage NMOS	NMOSMH	HV	1.80	170	65	40	20
High Voltage PMOS	PMOSMH	HV	-1.90	75	-55	36	20
High Voltage NDMOS	NMOSMD	HV	2.00	190	80	50	20
Extended HV NMOS	NMHE	XHV	1.95	140	95	60	20
Extended HV PMOS	PMHE	XHV	-0.85	140	-80	60	20
Extended HV DMOS	NMDSE	XHV	1.95	200	80	60	20

Note: The listed devices are examples only.

Bipolar Transistors							
Device	Device Name	available only with	VBE [mV]	BETA	VA [V]	BVCEO [V]	Max VCE [V]
Vertical PNP, Collector on Bulk	VERT15		660	12	> 100	> 7	5.5
Isolated Lateral PNP	LAT3		620	90	12	> 7	5.5
Vertical PNP, Collector on Bulk	VERT5H	HV	670	70	> 80	50	40
Isolated Vertical NPN	VERTN1	HV	650	200	30	40	10

Junction FETs								
Device	Device Name	available only with	Vpinch [V]	max VDB [V]	BVDSS [V]	IDS [ $\mu\text{A}$ ]	RON [ $\text{k}\Omega$ ]	note
Pinched N-Well Resistor	RNPINCH	HV	4	30 (35)	40	7		per $\mu\text{m}$ width
N-Channel Junction FET	NJFET10	HV	4	50 (55)	60	1200	2.5	fixed layout

> Device Parameters (continued)

**Passive Devices** (typical data)

Capacitors							
Device	Device Name	available only with	Area Cap [fF/μm <sup>2</sup> ]	BV [V]	Voltage coefficient [ppm/V]	Temp. coefficient [10 <sup>-3</sup> /K]	Max VCC [V]
POLY1-MET1-MET2 Sandwich	CSANDWT		0.09				50 (55)
DNTUB-POLY1-MET1-MET2 Sandwich	CSANDW	HV	0.18				50 (55)
Poly1-Poly2	CPOLY	Poly2	0.86	30	30	0.03	5.5 (7)

Resistors and Conductors							
Device	Element	available only with	RS [Ω/□]	Thickness [μm]	Temp. coefficient [10 <sup>-3</sup> /K]	Max Current Density [mA/μm]	Max VTB [V]
Poly Silicon	POLY1		32	0.30	0.7	0.45	50 (55)
	POLYH	High Res	1200	0.30	-1.2	0.18	50 (55)
	POLYM	High Res	130	0.30	0.35	0.40	50 (55)
	POLY2	Poly 2	33	0.30	0.7	0.45	50 (55)
Diffusion	NDIFF		42	0.30	1.5		8 (10)
	PDIFF		55	0,50	1.6		8 (10)
Well	NWELL		650	4.0	6.3		8 (10)
	DNTUB	HV	600	7.0	6.3		50 (55)
	SNTUB	HV	2300	5.5	6.5		50 (55)
	PWELL	HV	5000	1.6	4.6		45 (50)
Metal	MET1		0.07	0.7	3.0	0.9	30
	MET2		0.035	1.0	3.0	3.0	60
	MET3	met 3	0.012	2.3		7.0	60

> Digital Core Cells

X-FAB provides different core cells optimised for most typical applications. The standard core library includes more than 200 cells. Functionality and layouts are optimised for best synthesis results in high speed applications. The low power library offers 130 cells optimised for low power and area. These cells are most suitable for blocks running up to 100 MHz clock frequency.

Both standard and low power libraries are available in an "isolated" version. NMOS devices are placed in P-wells. The P-wells are placed in deep N-wells. Therefore NMOS devices do not have a common bulk.

The main advantages of isolated libraries are:

- Reduced substrate noise
- Superior latch-up and EMC immunity
- Bulk potential independent from substrate

These libraries are most suitable for low-noise mixed-signal applications and for products with high EMC requirements, such as automotive IC's.

"Isolated" libraries require HV process option. If HV option is not used, substrate noise can be reduced by using separate bulk wire library.

> Digital I/O Cells

I/O cells are available for 5 V and 3.3 V operation voltage. Two I/O ring systems are available for pad-limited and for core limited designs. Pad-limited cell height is 514.6 μm with 115 μm bond

pad pitch. I/O cells for core limited design have 231.3 μm height with variable bond pad pitch (>200 μm).

Input	CMOS	TTL	Pull-up	Pull-down	Output
Standard Input	■	■	■	■	
Schmitt-Trigger	■	■	■	■	
Bi-directional	■	■	■	■	1 - 8 mA (24 mA)
Slew-Rate Control Option	■	■		■	4 - 8 mA (24 mA)

Output	1 mA	2 mA	4 mA	8 mA	16 mA	24 mA
Standard	■	■	■	■	■	■
Slew-Rate Control Option			■	■	■	■
3-State	■	■	■	■	■	■
Open Drain	■	■	■	■	■	■

> Analog Primitive Devices and Models

A very wide range of different analogue primitives enable analogue designers to develop sophisticated, high precision, reliable analogue and high voltage circuits. See section "Devices and their operating conditions" for details.

High performance process modules, well defined primitive devices and accurate device models are the key success factors for analogue and mixed-signal design. Combined with X-FAB's CAE support kit "TheKit" and state of the art design methodologies first right analogue mixed-signal designs are reality.

X-FAB supports BSIM3 models as the present SPICE model standard for MOS transistors. Bipolar transistors are modelled using the Gummel-Poon model for a given emitter size. Well resistors have a non-linear terminal-voltage and bulk-voltage

dependence. These resistances have to be simulated with the 3-terminal SPICE JFET model.

Model sets for most popular analogue simulators, e.g. Spectre, HSPICE and PSPICE are provided.

The same characterisation and modelling effort is spent for parasitic devices and 3<sup>rd</sup> order parameters which are usually very important for analogue design.

The matching behaviour of MOS transistors, bipolar transistors, resistors and capacitors is very intensively investigated and characterised. Final matching parameters are extracted for all active and most of passive elements. These parameters are used at simulator model implementation for Monte Carlo simulation.

> Examples for measured and modeled parameter characteristics

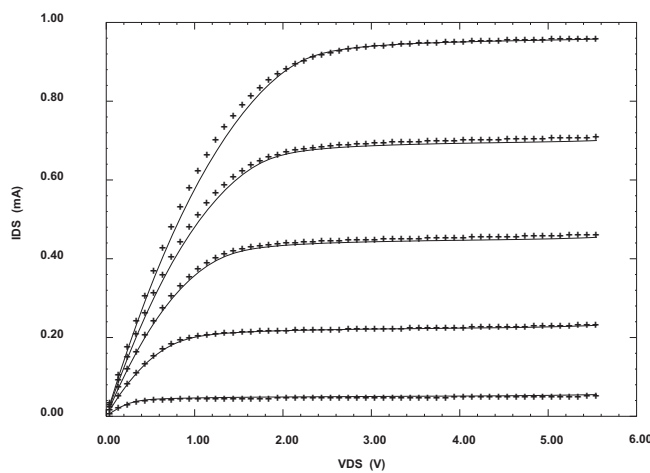


Figure 4: NMOS output characteristic  
W/L = 3/1, VGS = 1.4, 2.3, 3.2, 4.1, 5 V  
+ = measured, solid line = BSIM3v3 model

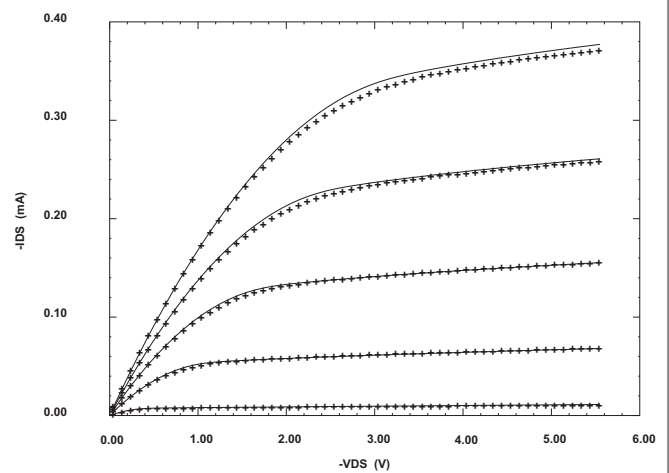


Figure 5: PMOS output characteristic  
W/L = 3/1, -VGS = 1.4, 2.3, 3.2, 4.1, 5 V  
+ = measured, solid line = BSIM3v3 model

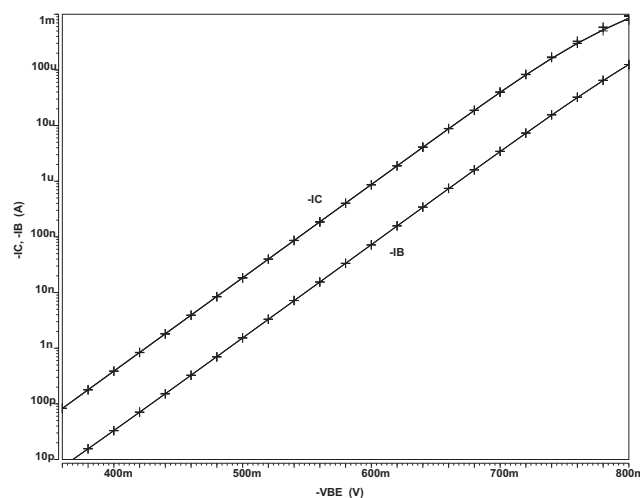


Figure 6: Gummel plot of vertical PNP bipolar transistor VERT15  
+ = measured, solid line = SPICE model

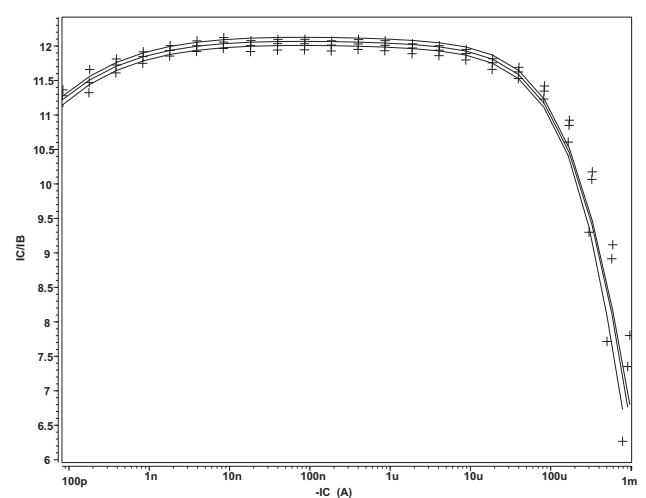


Figure 7: Current gain of vertical PNP bipolar transistor VERT15  
+ = measured, solid line = SPICE model

Examples for measured and modeled parameter characteristics (continued)

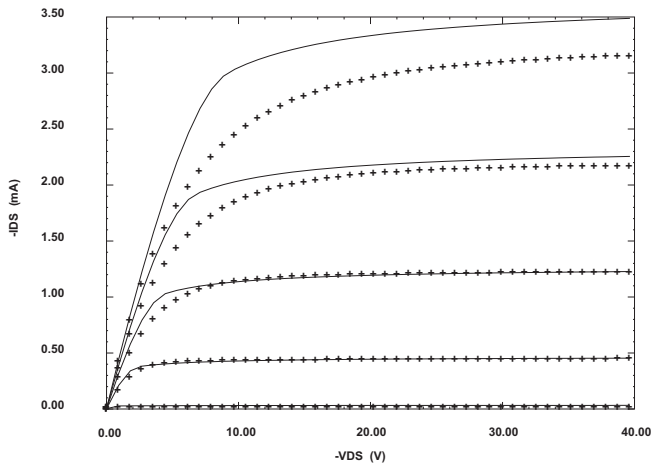


Figure 8: PMOSMH output characteristic  
 $W/L = 40/3$ ,  $-V_{GS} = 2.67, 5, 7.33, 9.67, 12$  V  
 $V_{SB} = 0$  V, + = measured, solid line = BSIM3v3 model

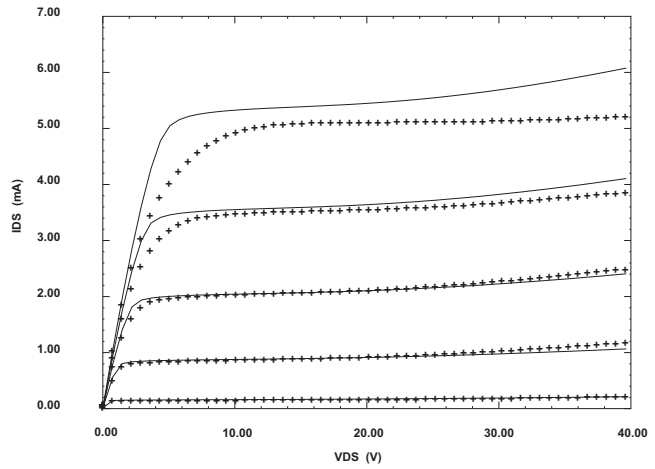


Figure 9: NMOSTD output characteristic  
 $W/L = 40/2$ ,  $V_{GS} = 1.4, 2.3, 3.2, 4.1, 5$  V  
 $V_{SB} = 0$  V, + = measured, solid line = BSIM3v3 model

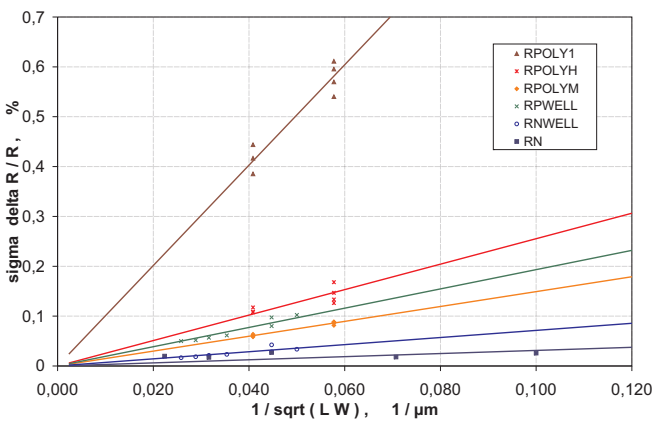


Figure 10: resistor matching

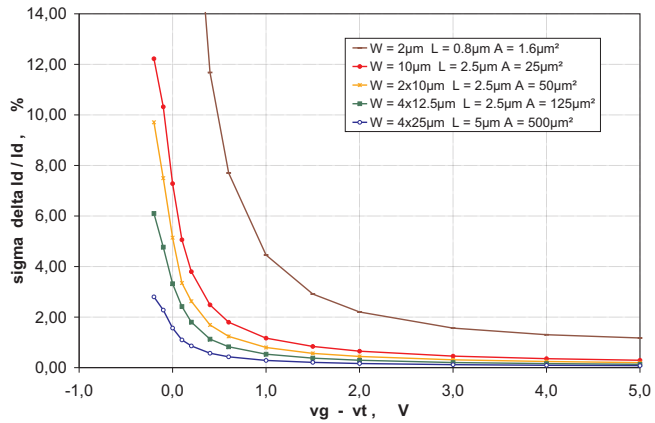


Figure 11: drain current matching NMOS4

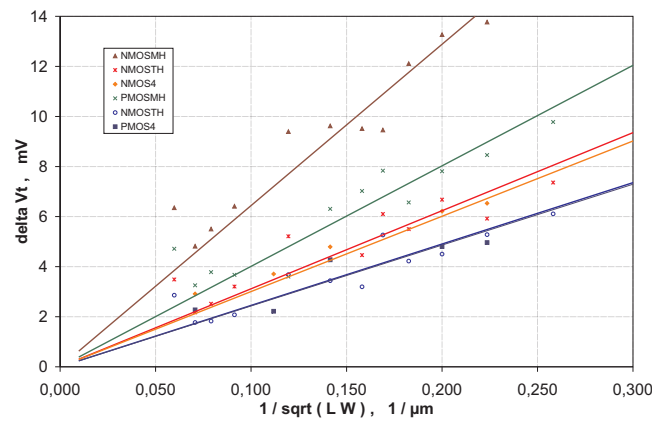


Figure 12: treshold voltage matching

> Analog Library Cells

Many analogue and mixed-signal design projects are started in old technologies because designers want to re-use existing analogue cells.

For an easy migration to X-FAB's high performance CX08 process an increasing number of general purpose analogue cells are provided.

Bandgaps										
Bandgap name	Bandgap voltage (unloaded) [V]		Temperature Coefficient [ppm/°C]		Supply current [µA]	Supply voltage [V]				
ABGPC01	1.275 ± 100 mV		+60 for T < 25°C - 60 for T > 25°C		35	3 ... 6				
ABGPC04	1.295 ± 50 mV				35	3 ... 6				
ABGPC02	1.215 ± 100 mV				35	3 ... 6				
ABGPC03	1.225 ± 50 mV				35	3 ... 6				
BG03	1.26 ± 90 mV		-100 ... 100		16	4.5 ... 5.5				
Bias Cells										
Bias voltage source name	Bias voltage VBP for PMOS [V]		Current through VDP-stage [µA]		Bias voltage VBN for NMOS [V]		Current through VBN-stage [µA]		Supply current [µA]	
ABIAC01	VDD - 1.16		12		1.26		6		18	
ABIAC02	VDD - 1.32		23.5		1.44		11		34.5	
ABIAC03	VDD - 1.05		6.4		1.13		3		9.4	
Operational Amplifiers										
OpAmp	VOL [V]	VOH [V]	VICR [V]	VIO [mV]	AVD [dB]	B1 [kHz]	SR [V/µs]	Φm	IDD [µA]	Load
AOPAC01	0.05	3.4	0 ... V <sub>DD</sub> - 1.5	< 10	80	85	0.06 : 0.06	60°	7.5	1000kΩ/100pF
AOPAC02	0.05	3.5	0 ... V <sub>DD</sub> - 1.5	< 10	80	1100	1.15 : 1.15	60°	100	100kΩ/100pF
AOPAC03	0.1	3.4	0 ... V <sub>DD</sub> - 1.5	< 10	80	8500	7.0 : 7.0	60°	500	10kΩ/100pF
AOPAC04	0.05	3.5	0 ... V <sub>DD</sub> - 1.5	< 3	80	1200	0.9 : 1.25	60°	100	100kΩ/100pF
AOPAC05	1	4.95	1.5 ... V <sub>DD</sub>	< 10	80	130	0.05 : 0.08	60°	8.5	1000kΩ/100pF
AOPAC06	1	4.9	1.5 ... V <sub>DD</sub>	< 10	80	1000	0.5 : 0.5	60°	90	100kΩ/100pF
AOPAC07	1.2	4.7	1.5 ... V <sub>DD</sub>	< 10	80	5600	2.2 : 2.6	60°	520	10kΩ/100pF
AOPAC08	1	4.9	1.5 ... V <sub>DD</sub>	< 5	80	1000	0.4 : 0.4	60°	90	100kΩ/100pF
AOPAC09	0.1	V <sub>DD</sub> - 0.1	0 ... V <sub>DD</sub> - 1.5	< 10	90	2000	1.3 : 1.7	60°	320	10kΩ/100pF
AOPAC10	0.1	V <sub>DD</sub> - 0.1	0 ... V <sub>DD</sub>	< 10	100	1500	1.0 : 1.2	60°	410	10kΩ/100pF
AOPAC11	0.1	V <sub>DD</sub> - 0.1	0 ... V <sub>DD</sub>	< 5	100	1250	0.8 : 1.0	60°	410	10kΩ/100pF
AOPAC12	0.1	V <sub>DD</sub> - 0.1	0 ... V <sub>DD</sub> - 1.5	< 3	100	1800	1.2 : 1.5	60°	320	10kΩ/100pF
AOPAC13	0.1	V <sub>DD</sub> - 0.1	0 ... V <sub>DD</sub> - 1.5	< 3	100	4000	2.9 : 3.2	60°	1000	2kΩ/100pF
OP01B	0	V <sub>DD</sub>	0.2 ... V <sub>DD</sub> - 0.75	< 10	99	2200	12.9 : 13.4	80°	380	10MΩ/10pF
OP02B	0	V <sub>DD</sub>	0.1 ... V <sub>DD</sub> - 1.70	< 7	110	5200	6.8 : 6.4	97°	210	10MΩ/10pF
OP03B	0.05	V <sub>DD</sub> - 0.1	0.1 ... V <sub>DD</sub> - 1.60	< 5	120	3400	10.8 : 11.9	72°	350	10MΩ/50pF
OP05B	0.05	V <sub>DD</sub> - 0.15	0.2 ... V <sub>DD</sub> - 0.72	< 10	106	2600	1.4 : 4.0	75°	60	10MΩ/10pF
OPEA01	0.05	V <sub>DD</sub> - 0.12	0.2 ... V <sub>DD</sub> - 0.73	< 10	113	2400	2.8 : 2.7	56°	630	2kΩ/1000pF
OPLD01	0.0	V <sub>DD</sub>	0.15 ... V <sub>DD</sub> - 0.80	< 10	112	400	0.8 : 0.8	63°	550	1MΩ/5000pF
OP-VIDEO	0.8	V <sub>DD</sub> - 1.0	0.8 ... V <sub>DD</sub> - 1.0	< 10	88	47300	20.5 : 19	72°	5100	75Ω/20pF
Note: All AOPACxx OpAmps feature a standby mode.										
Comparators										
Analog Comparator name	Common-mode input voltage range [V]		Propagation delay time for 50 mV overdrive [ns]		Propagation delay time for 500 mV overdrive [ns]		Input offset voltage [mV]		Supply current [µA]	
ACMPC01	1.5 ... VDD		520 / 260		250 / 200		< 10		5	
ACMPC02	1.5 ... VDD		670 / 410		125 / 600		< 5		5	
ACMPC03	1.5 ... VDD		130 / 60		20 / 45		< 5		85	
ACMPC04	0 ... VDD - 1.5		320 / 780		225 / 325		< 10		5	
ACMPC05	0 ... VDD - 1.5		460 / 950		890 / 170		< 3		5	
ACMPC06	0 ... VDD - 1.5		65 / 170		55 / 35		< 3		85	
ACMPC09	1.5 ... VDD		100 / 40		40 / 20		< 10		85	
ACMPC10	0 ... VDD - 1.5		60 / 165		25 / 60		< 10		85	
Note: All Comparators feature a standby mode.										

> Analog Library Cells (continued)

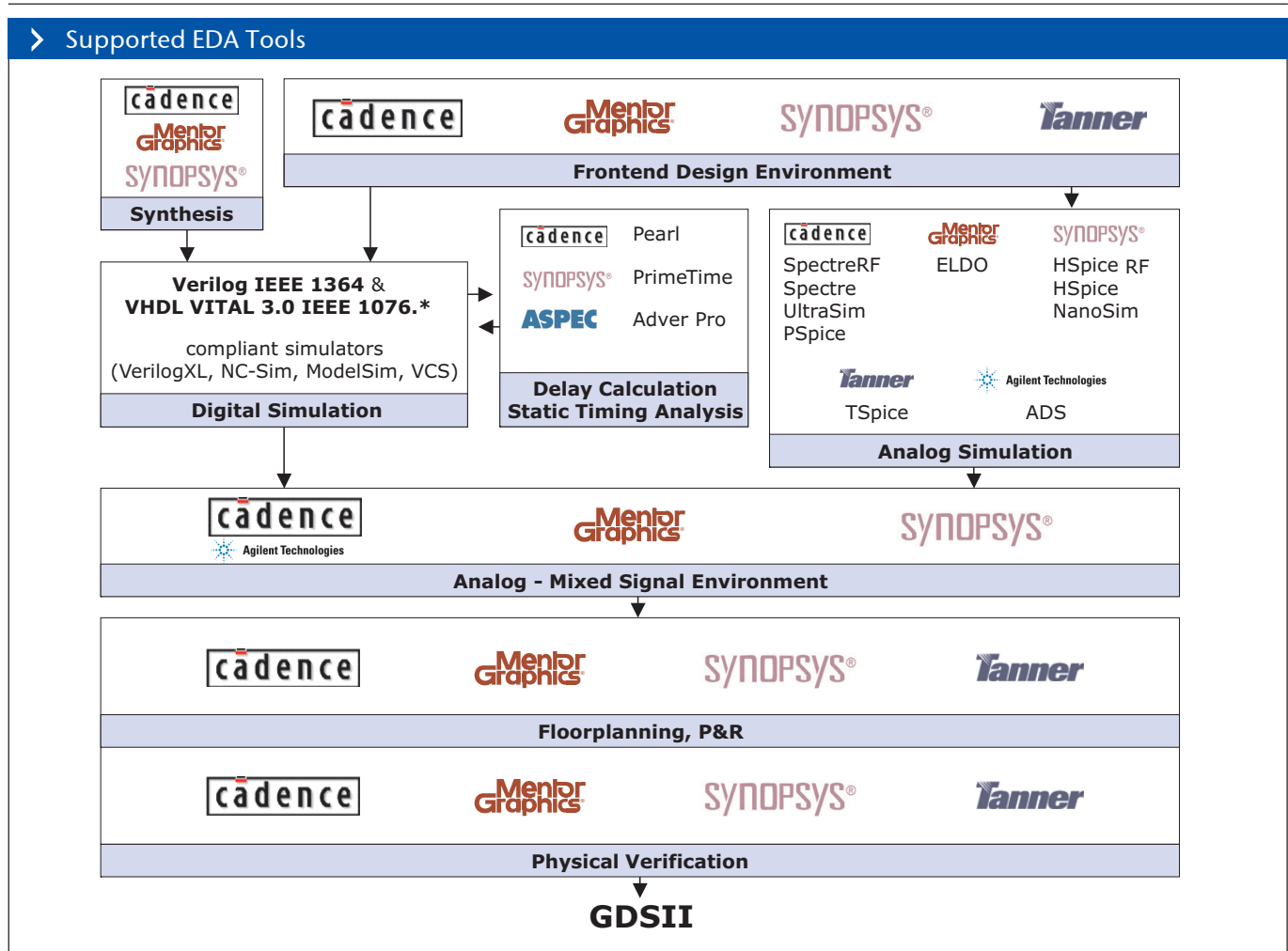
ADC / DAC							
Converter name	Function	Principle	Resolution [Bits]	Accuracy [LSB]	Conversion time [µs]	Supply current [µA]	Comment
AADC01	ADC	successive approximation	8	± 0.5	10	600	VREFH > 3V
AADCC02	ADC	successive approximation	8	± 0.5	10	600	VREFH < 3.5V
ADC02	ADC	successive approximation	8	± 0.5	50	500	
ADC04	ADC	successive approximation	8	± 0.5	50	300	
ADC10	ADC	successive approximation	10	± 0.5	11	860	sample & hold
ADC8	ADC	successive approximation	8	± 0.5	9	1000	sample & hold
ADACC11	DAC	successive approximation	8	± 0.5	0.5	500	
DAC8	DAC	resistor strings	8	± 0.5	1	150	
DAC10	DAC	resistor strings	10	± 0.5	1	200	
VDAC8	DAC		8	± 0.5	0.11		

RC Oscillators	
1Pad, external RC, 10% accuracy (industrial + inaccuracy of ext. RC) 2Pads, external RC, 5% accuracy (industrial + inaccuracy of ext. RC) Internal RC, 50% accuracy (industrial) Frequency range from Hz to 20 MHz	
ARCO01G	2-Pin RC-Oscillator, external RC [50 kΩ, 100 pF: 125 Hz (I=70µA)], Frequency Range: ca. 20Hz up to 500 kHz, IO-Cell: 5-ring supply system
ARCO03F	1- Pin RC-Oscillator, external RC [82.5 kΩ, 220 nF: 77 Hz (I=35µA)], Frequency Range: ca. 20Hz up to 500 kHz, IO-Cell: flat 2-ring supply system

Crystal Oscillators							
Crystal Oscillator name	Frequency [MHz]	Supply voltage range V <sub>DD</sub> [V]	Supply current (specified at V <sub>DD</sub> =5V) [mA]		Oscillator supply voltage range VOS [V]	Oscillator supply current (specified at V <sub>DD</sub> =5V, VOS=3V) [mA]	
			typical	maximum		typical	maximum
AXTOC01G	0.032	3.5 ... 6.0	2.5 e-6	5 e-6	-	-	-
AXTOC03G	1 ... 2	3.5 ... 6.0			2.7 ... 5.5	0.20	0.35
AXTOC04G	2 ... 4	3.5 ... 6.0			2.7 ... 5.5	0.29	0.50
AXTOC05G	4 ... 8	3.5 ... 6.0			2.7 ... 5.5	0.75	1.2
AXTOC06G	8 ... 14	3.5 ... 6.0			2.7 ... 5.5	1.8	3.0
AXTOC07G	14 ... 26	3.5 ... 6.0			2.7 ... 5.5	3.2	5.2
AXTOC08F	4 6 (ceramic)	3.0 ... 3.6	0.46 0.68	0.75 1.2	-	-	-
AXTOC09G	32	4.5 ... 5.5	3.0	6.0	-	-	-
AXTOC10G	4	4.5 ... 5.5	0.315	0.42			

Note: All crystal oscillators have two pads for connection to the crystal.





> X-FAB's IC Development Kit "TheKit"

**The X-FAB IC Development Kit** is a complete solution for easy access to X-FAB technologies. TheKit is the best interface between standard CAE tools and X-FAB's processes and libraries. TheKit is available in two versions, the Master Kit and the Master Kit Plus. Both versions contain documentation, a set of software programs and utilities, digital and I/O libraries which contain full front-

end and back-end information for the development of digital, analog and mixed signal circuits. Tutorials and application notes are included as well. The Master Kit Plus additionally provides a set of general purpose analog functions mentioned in section "Analog Library Cells" and is subject to a particular license.

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