Triple Well Smart-BCD Process

with only 11 Mask Layers* –

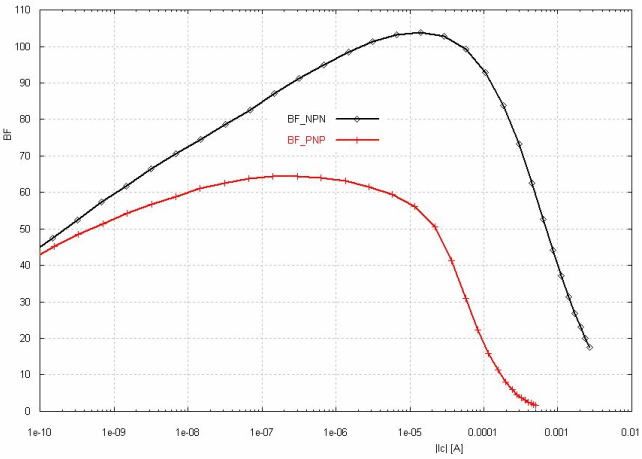
A Process of Unsurpassed Simplicity and Modularity

* Masks for two metal layers included

Bipolar NPN + PNP transistors

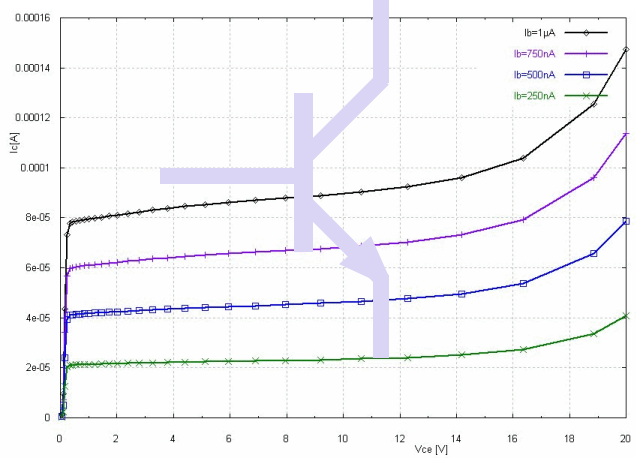
- High current gain in a wide current range
- Minimum VCEo = 20V for NPN and VCEo = 25V for PNP
- High Early voltage

The excellent characteristics of the bipolar transistors makes them the first choice for analog designs.
A high current gain over more than 6 orders of magnitude in collector current provides a wide dynamic range.
Power transistors for currents in the order of 1A can be designed.
Standard transistors allow easy designs for voltages up approx. 20V, and if higher voltages are needed, special high-voltage transistors for supply voltages up to 80V are available.
Super-beta NPN transistors with a gain of typically 1000 complete the range of bipolar transistors.

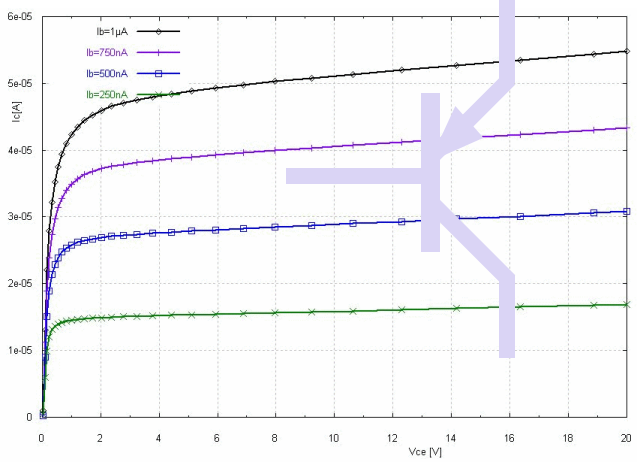


Current gain of NPN and PNP vs. Collector current

Type	Package densities	Gain B



NPN output characteristics



PNP output characteristics

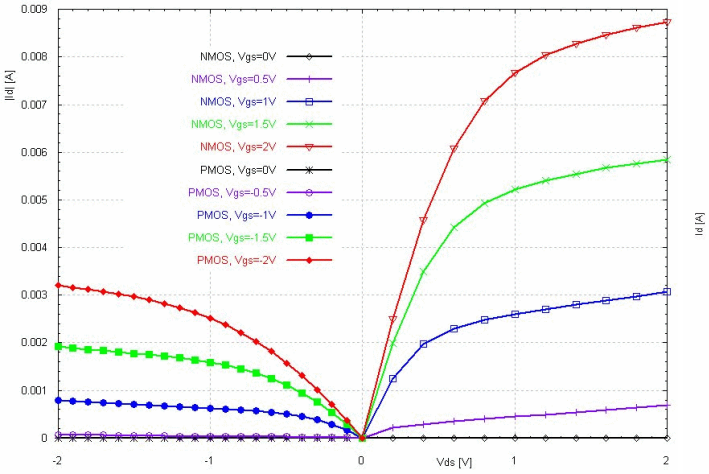
Smart-BCD

MOS
NMOS + PMOS
transistors

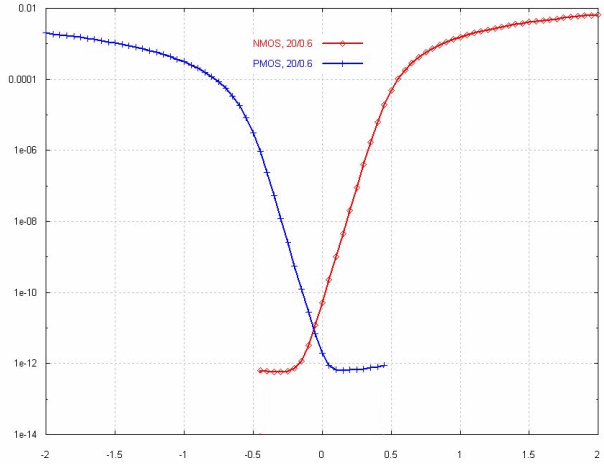
- N-channel and P-channel for Vcc = 2V
- Gate length 0.6 m
- N-channel and P-channel DMOS transistors with V_{DSmax}=10V and low RDSon without extra process layers

The Smart-BCD process offers a symmetrical pair of MOS transistors for analog and digital applications. N-channel and P-channel transistors are suitable for supply voltages of 2V and below.

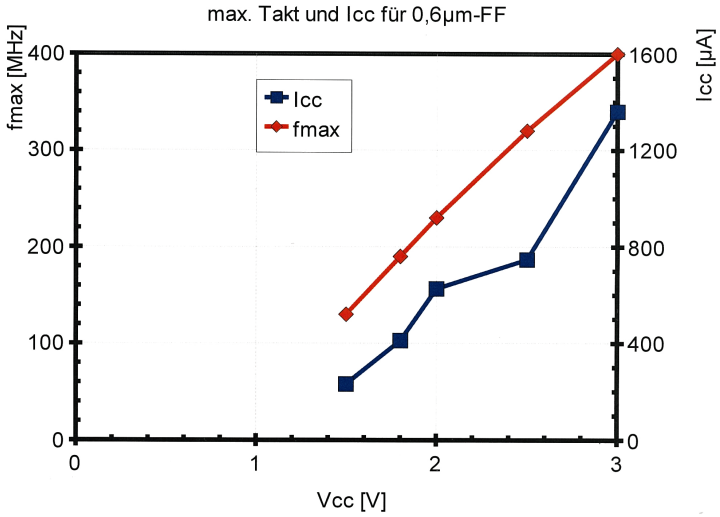
Type	KP (transconductance parameter)	VTh (threshold voltage)
NMOS	220 A/V²	0.5V
PMOS	60 A/V²	-0.5V



Output characteristics of a CMOS pair
(W/L=20/0.6: V_{GS}=0 / 0.5 / 1.0 /1.5 /2.0V)



Semi-logarithmic plot of NMOS and PMOS transfer characteristics



Maximum clock rate (blue)
and supply current (red)
of flip-flop with 0.6 m gate length

- N-channel DMOS transistor:
  RDSon = 120mΩ•mm²
  V_{DSmax} = 10V
  BV_{DS} = 18V
- P-channel DMOS transistor
  RDSon = 480mΩ•mm²
  V_{DSmax} = 10V
  BV_{DS} = 18V

Smart-BCD

Standard and Zener Diodes

- PN diodes
- Zener diodes for 8V and 75V

PN diodes	max. reverse voltage 6V currents up to approx. 1A
Zener diodes	Zener voltage typ. 8V
HV zener diodes	Zener voltage typ. 75V

Resistors

- Implanted resistors in individual wells

P-type implanted resistor in individual wells	2 kΩ/square
N-type implanted resistor	2 kΩ/square

Capacitors

- Junction capacitors
- Voltage independent MIM capacitors

Junction capacitor (at V_{cap}=0V)	0.23 fF/ m²
MIM capacitor (metal-insulator-metal)	1 ~ 2.5 fF/ m²
(MIM capacitor requires one extra mask layer)	

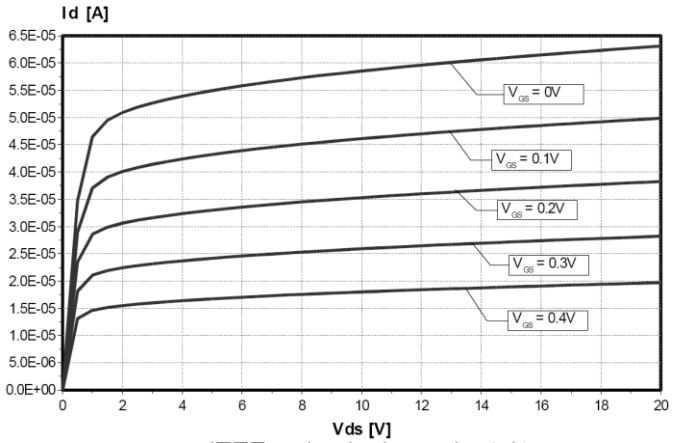
Junction FETs Current Diodes in Smart-BCD

- No extra mask layers
- Easy to use bipolar current sources or sinks

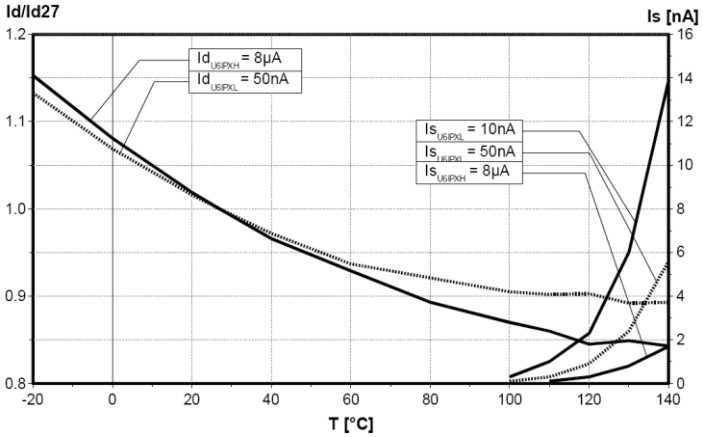
JFETs

are available within the standard process:

- ! Pinch-off voltage typ. 0.8V
- ! High gate-substrate voltage of up to 80V allowed for high-voltage types
- ! Maximum gate-source and gate-drain voltage 70V for high-voltage types
- ! Very low gate-drain current
- ! Currents from 10nA to 100 A



JFET output characteristics



Temperature dependency of biplar constant current diodes, normalized at 27°C

Bipolar Constant Current Diodes

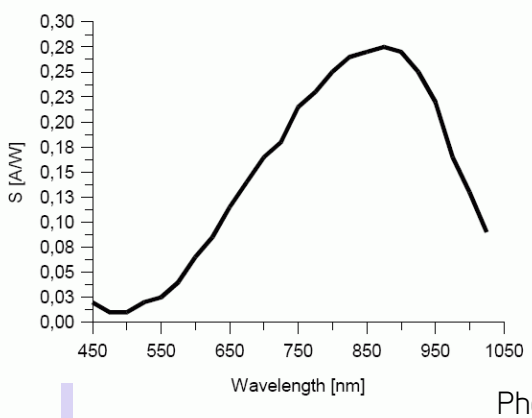
provide an easy and robust way to generate constant currents within a circuit:

- ! Very high output impedance from 1V on
- ! Excellent long-term stability
- ! Dynamically stable, no oscillations, no parasitic coupling, other than with bias current generation through current mirrors
- ! High voltages up to 80V possible
- ! Currents from 10nA to 100 A

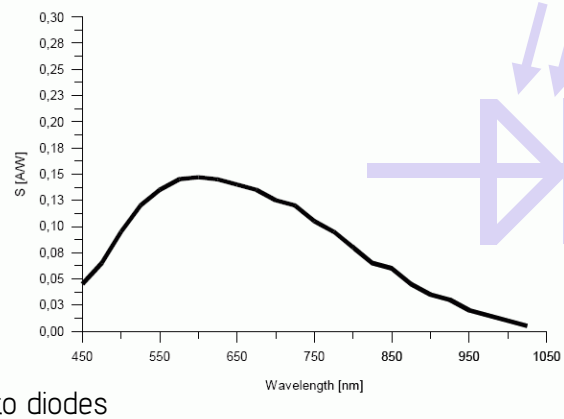
Optical Sensors
Diodes and Transistors

Smart-BCD process allows two types of photodiodes:
Type 1: maximum sensitivity at red/near infrared
Type 2: maximum sensitivity at visible wavelengths (yellow/orange)

- Photodiodes for visible and near infrared range
- Phototransistors and super-beta phototransistors
- Low dark current, excellent dynamic range
- No additional mask layers required



Spectral sensitivity NWELL/PSUB

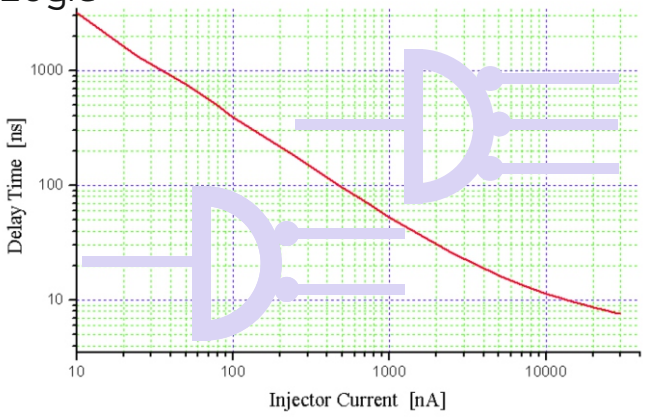


Spectral sensitivity NWELL/PBAS

Photo diodes

Production of phototransistors is possible without the need for extra mask layers. A sensitivity of typ. 17A/W at 890nm wavelength can be reached. In addition, phototransistors with super-beta characteristics offer a sensitivity of 130A/W. In a differential stage, compensating the dark current, extreme levels of sensitivity even at elevated temperatures can be achieved.

Bipolar CCL
Logic



Propagation delay t_{PD} as a function of the injector current

- Constant current, therefore low interference with sensitive analog circuit blocks
- Minimum supply voltage less than 1V

With the Smart-BCD process special logic gates in the CCL technique (constant current logic) can be produced. A vertical injector structure is used, thus providing a high gate current gain at lowest currents.
Delay times can be adjusted by changing the injector current, minimizing the power dissipation. A simple ring oscillator can be designed as a current controlled oscillator, with frequency

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