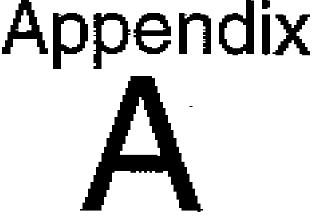

Orbit's CN20 Process

This appendix describes Orbit Semiconductor's[1] 2.0 μm double-poly, double-metal, n-well process (CN20). The process specifications, electrical and SPICE parameters, and design rules are given. The purpose is to give students the information they need to design a CMOS integrated circuit using an actual CMOS process. Commonly used symbols and physical constants are shown in Tables A.1 and A.2.

Name	Symbol	Value
terra	T	10^{12}
giga	G	10^{9}
mega	MEG	10^{6}
kilo	k	10^{3}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}

Table A.1 Multiplier Symbols.

[1] Orbit Semiconductor, Inc., 1215 Bordeaux Drive, Sunnyvale, CA. 94089. Tel: (408) 744-1800.

Name	Symbol	Value/Units
Vacuum dielectric constant	ε_0	8.85 aF/µm
Silicon dielectric constant	ε_{si}	$11.7\varepsilon_0$
SiO_2 dielectric constant	ε_{ox}	$3.97\varepsilon_0$
SiN_3 dielectric constant	ε_{Ni}	$\approx 16\varepsilon_0$
Boltzmann's constant	k	1.38×10^{-23} J/K
Electronic charge	q	1.6×10^{-19} C
Temperature	T	K
Thermal voltage	V_T	kT/q = 26 mV @ 300 K

Table A.2 Useful physical constants.

	Thickness or Separation µm	Plate Cap. aF/µm²			Fringe Cap. aF/µm		
		Min	Typ	Max	Min	Typ	Max
Poly1 gate oxide	0.040 +/– 0.003	803	863	933			
Poly2 gate oxide	0.046 +/– 0.005	677	750	842			
Poly1 to subs. (FOX)	0.600 +/– 0.050	53	58	63	85	88	92
Poly1 to poly2	0.070 +/– 0.008	443	493	557			
Poly1/2 thickness	0.400 +/– 0.030						
Metal1 thickness	0.600 +/– 0.060						
Metal2 thickness	1.150 +/– 0.120						
Metal1 to poly1/2	0.900 +/– 0.100	35	38	43	84	88	93
Metal1 to substrate	1.500 +/– 0.150	21	23	26	75	79	82
Metal1 to diffusion	0.900 +/– 0.100	35	38	43	84	88	93
Metal2 to poly1	1.900 +/– 0.200	16	18	20	83	87	91
Metal2 to substrate	2.500 +/– 0.250	13	14	15	78	81	85
Metal2 to diffusion	1.900 +/– 0.200	16	18	20	83	87	91
Metal2 to metal1	1.000 +/– 0.100	31	35	38	95	100	104

Table A.3 Process thicknesses and distances

A.1 Process Specifications

The physical distances, thicknesses, and capacitances for the CN20 process are shown in Table A.3. The main use of this table is in determining the parasitic capacitances in a particular layout.

A.1.1 Electrical Specifications

The following six tables describe the electrical characteristics of the p- and n-channel MOSFETs and the lateral bipolar junction transistor available in the CN20 process.

P-channel device L = 2 µm (Poly1)	**Min**	**Typ**	**Max**
Threshold voltage V_{THP}, (V)	0.6	0.8	1.1
Gamma ($V^{1/2}$)	0.45	0.55	0.65
KP = $(MUZ)(C'_{ox})$ (µA/V²) (V_{SD} = 0.1 V with V_{SG} = 2 V to 3 V)	12	15	17
Punchthrough for minimum length channel (V)	10	14	16
Subthreshold slope^{-1} (mV/decade)	90	100	110
Delta length (DL) = $L_{drawn} - L_{eff}$ (µm)	0.7	0.4	0.1

Table A.4 Electrical parameters for the p-channel MOSFET.

N-channel device L = 2 µm (Poly1)	**Min**	**Typ**	**Max**
Threshold Voltage V_{THP}, (V)	0.6	0.8	1.1
Gamma ($V^{1/2}$)	0.15	0.25	0.35
KP = $(MUZ)(C'_{ox})$ (µA/V²) (V_{DS} = 0.1V with V_{GS} = 2 V to 3 V)	40	46	52
Punchthrough for minimum length channel (V)	10	14	16
Subthreshold slope^{-1} (mV/decade)	90	100	110
Delta length (DL) = $L_{drawn} - L_{eff}$ (µm)	0.6	0.3	0

Table A.5 Electrical parameters for the n-channel MOSFET.

NPN in the n-well Beta = 80-200 @ I_B = 1μA	
BV_{EBO}	10 V
BV_{CBO}	≥ 10 V
BV_{CES}	> 10 V
BV_{CBO}	≥ 60 V
P- Base Xj	0.45 to 0.5 μm
N+ emitter	≈ 0.3 μm
R collector	1.0 ± 0.2 kΩ/sq
P- base resistance	1.2 ± 0.2 kΩ/sq
Early voltage	>30 V

Table A.6 Electrical characteristics of the junction-isolated NPN.

Sheet Resistance (Ω/square)	Min	Typ	Max
P+ active	50	70	100
N+ active	20	28	40
N-well (with field implant)	2,000	2,500	3,000
Poly1	15	21	30
Poly2	18	25	30
Metal1	0.05	0.06	0.06
Metal2	0.02	0.03	0.03
P - substrate (ohm-cm)	30	45	60

Table A.7 Sheet resistances.

Contact Resistance (Single contact 2 μm × 2 μm)	Min	Max
Metal1 to p+ active	35	75
Metal1 to n+ active	20	50
Metal1 to poly1	20	50
Metal1 to poly2	20	50
Metal1 to metal2	0.05	0.08

Table A.8 Contact resistances.

Field Inversion and Breakdown Voltages (V)	Min	Typ	Max
n-channel poly1 field inversion	10	14	
n-channel metal1 field inversion	10	14	
p-channel poly1 field inversion		−14	−10
p-channel metal1 field inversion		−14	−10
n-diffusion to substrate junction breakdown		14	16
p-diffusion to well breakdown		15	18
n-Well to p-substrate junction breakdown		50	90

Table A.9 Field inversion and breakdown voltages.

A.1.2 N-Channel SPICE Models

This section describes the level 2 and BSIM SPICE models and shows characteristics for various-sized devices. These models are located in the file **spice.inf** in C:\LASI5\CN20.

```
.MODEL CMOSN NMOS LEVEL=2
+PHI=0.600000 TOX=4.3500E-08 XJ=0.200000U  TPG=1
+ VTO=0.8756 DELTA=8.5650E+00 LD=2.3950E-07 KP=4.5494E-05
+ UO=573.1 UEXP=1.5920E-01 UCRIT=5.9160E+04 RSH=1.0310E+01
+ GAMMA=0.4179 NSUB=3.3160E+15 NFS=8.1800E+12 VMAX=6.0280E+04
+ LAMBDA=2.9330E-02 CGDO=2.8518E-10 CGSO=2.8518E-10
+ CGBO=4.0921E-10 CJ=1.0375E-04 MJ=0.6604 CJSW=2.1694E-10
+ MJSW=0.178543 PB=0.800000
```

A.1.3 P-Channel SPICE Models

This section describes the level 2 and BSIM SPICE models and shows characteristics for various-sized devices. These models are located in the file **spice.inf** in C:\LASI5\CN20.

```
.MODEL CMOSP PMOS LEVEL=2
+PHI=0.600000 TOX=4.3500E-08 XJ=0.200000U TPG=-1
+ VTO=-0.8889 DELTA=4.8720E+00 LD=2.9230E-07 KP=1.5035E-05
+ UO=189.4 UEXP=2.7910E-01 UCRIT=9.5670E+04 RSH=1.8180E+01
+ GAMMA=0.7327 NSUB=1.0190E+16 NFS=6.1500E+12 VMAX=9.9990E+05
+ LAMBDA=4.2290E-02 CGDO=3.4805E-10 CGSO=3.4805E-10
+ CGBO=4.0305E-10 CJ=3.2456E-04 MJ=0.6044 CJSW=2.5430E-10
+ MJSW=0.244194 PB=0.800000
* Weff = Wdrawn - Delta_W
* The suggested Delta_W is -3.6560E-07
```