EE 330
Homework 5
Fall 2020
Due Wednesday September 16

Problem 1

Assume a resistor has a resistance of 1KΩ at T=273°K. If the TCR of this resistor is constant of value 1100 ppm/°C, what will be the resistance at T=300°K?

Problem 2

Assume a resistor has a resistance with a function $R(T) = 5T + 1000$ where T is in Celsius. If you use the values T=25°C and 47°C, what is the TCR of the resistor?

Problem 3

Consider a 5K resistor that is made by the series connection of two resistors. One of the resistors is a n+ doped 2KΩ polysilicon resistor with a TCR of -600 ppm/oC and the other is a p+ diffused silicon 3KΩ resistor with a TCR of 1000 ppm/oC. What is the TCR of the series combination?

Problem 4

Design a 500Ω resistor with a 1% accuracy in the AMI 06 process. Use Poly 1 for the resistor and a width-length ratio of an imaginary box enclosing the resistor should be 1:1. Sketch out the boxes and count the resistance. For the minimum width look at the design rules on Dr. Geiger's website.

Problem 5

Design a 100fF capacitor in the AMI 06 process. Your only restrictions are you need to use 3 layers to do so. Clearly specify which layers you are using for this capacitor. The layout of the capacitor can be either sketched or come from a Cadence layout.

Problem 6

If the voltage of a forward-biased p-n junction is varied between $0.5V$ and $0.6V$, what is the range in the diode current? Assume the junction area of the diode is $75\mu m^2$ and $J_S = 10^{-15}A/\mu m^2$

MOSIS WAFER ACCEPTANCE TESTS

RUN: T6AU VENDOR: AMIS
TECHNOLOGY: SCN05 FEATURE SIZE: 0.5 microns
Run type: SKD

INTRODUCTION: This report contains the lot average results obtained by MOSIS from measurements of MOSIS test structures on each wafer of this fabrication lot. SPICE parameters obtained from similar measurements on a selected wafer are also attached.

COMMENTS: American Microsystems, Inc. C5

TRANSISTOR PARAMETERS	W/L	N-CHANNEL	P-CHANNEL	UNITS
MINIMUM	3.0/0.6			
Vth		0.79	-0.92	volts
SHORT	20.0/0.6			
Idss		446	-239	uA/um
Vth		0.68	-0.90	volts
Vpt		10.0	-10.0	volts
WIDE	20.0/0.6			
Ids0		< 2.5	< 2.5	pA/um
LARGE	50/50			
Vth		0.68	-0.95	volts
Vjbkd		10.9	-11.6	volts
Ijlk		<50.0	<50.0	pA
Gamma		0.48	0.58	V^0.5
K' (Uo*Cox/2)		56.4	-18.2	uA/V^2
Low-field Mobility		463.87	149.69	cm^2/V*s

COMMENTS: Poly bias varies with design technology. To account for mask bias use the appropriate value for the parameter XL in your SPICE model card.

Design Technology	XL (um)	XW (um)
SCMOS_SUBM (lambda=0.30)	0.10	0.00
SCMOS (lambda=0.35)	0.00	0.20

FOX TRANSISTORS	GATE	N+ACTIVE	P+ACTIVE	UNITS
Vth	Poly	>15.0	<-15.0	volts

PROCESS PARAMETERS	N+	P+	POLY	PLY2_HR	POLY2	M1	M2	UNITS
Sheet Resistance	83.5	105.3	23.5	999	44.2	0.09	0.10	ohms/sq
Contact Resistance	64.9	149.7	17.3		29.2		0.97	ohms
Gate Oxide Thickness	142							angstrom

PROCESS PARAMETERS	M3	N\PLY	N_W	UNITS
Sheet Resistance	0.05	824	816	ohms/sq
Contact Resistance	0.79			ohms

COMMENTS: N\POLY is N-well under polysilicon.

CAPACITANCE PARAMETERS	N+	P+	POLY	POLY2	M1	M2	M3	N_W	UNITS
Area (substrate)	425	731	84		27	12	7	37	aF/um^2
Area (N+active)			2434		35	16	11		aF/um^2
Area (P+active)			2335						aF/um^2
Area (poly)				938	56	15	9		aF/um^2
Area (poly2)					49				aF/um^2
Area (metal1)						31	13		aF/um^2
Area (metal2)							35		aF/um^2
Fringe (substrate)	344	238			49	33	23		aF/um
Fringe (poly)					59	38	28		aF/um
Fringe (metal1)						51	34		aF/um
Fringe (metal2)							52		aF/um
Overlap (N+active)			232						aF/um
Overlap (P+active)			312						aF/um

CIRCUIT PARAMETERS			UNITS
Inverters	K		
Vinv	1.0	2.02	volts
Vinv	1.5	2.28	volts
Vol (100 uA)	2.0	0.13	volts
Voh (100 uA)	2.0	4.85	volts
Vinv	2.0	2.46	volts
Gain	2.0	-19.72	
Ring Oscillator Freq.			
DIV256 (31-stg,5.0V)		95.31	MHz
D256_WIDE (31-stg,5.0V)		147.94	MHz
Ring Oscillator Power			
DIV256 (31-stg,5.0V)		0.49	uW/MHz/gate
D256_WIDE (31-stg,5.0V)		1.01	uW/MHz/gate

COMMENTS: SUBMICRON

T6AU SPICE BSIM3 VERSION 3.1 PARAMETERS

SPICE 3f5 Level 8, Star-HSPICE Level 49, UTMOST Level 8

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* DATE: Jan 11/07
* LOT: T6AU                  WAF: 7101
* Temperature_parameters=Default
.MODEL CMOSN NMOS (                                 LEVEL   = 49
+VERSION = 3.1            TNOM    = 27              TOX     = 1.42E-8
+XJ      = 1.5E-7         NCH     = 1.7E17          VTH0    = 0.629035
+K1      = 0.8976376      K2      = -0.09255        K3      = 24.0984767
+K3B     = -8.2369696     W0      = 1.041146E-8     NLX     = 1E-9
+DVT0W   = 0              DVT1W   = 0               DVT2W   = 0
+DVT0    = 2.7123969      DVT1    = 0.4232931       DVT2    = -0.1403765
+U0      = 451.2322004    UA      = 3.091785E-13    UB      = 1.702517E-18
+UC      = 1.22401E-11    VSAT    = 1.715884E5      A0      = 0.6580918
+AGS     = 0.130484       B0      = 2.446405E-6     B1      = 5E-6
+KETA    = -3.043349E-3   A1      = 8.18159E-7      A2      = 0.3363058
+RDSW    = 1.367055E3     PRWG    = 0.0328586       PRWB    = 0.0104806
+WR      = 1              WINT    = 2.443677E-7     LINT    = 6.999776E-8
+XL      = 1E-7           XW      = 0               DWG     = -1.256454E-8
+DWB     = 3.676235E-8    VOFF    = -1.493503E-4    NFACTOR = 1.0354201
+CIT     = 0              CDSC    = 2.4E-4          CDSCD   = 0
+CDSCB   = 0              ETA0    = 2.342963E-3     ETAB    = -1.5324E-4
+DSUB    = 0.0764123      PCLM    = 2.5941582       PDIBLC1 = 0.8187825
+PDIBLC2 = 2.366707E-3    PDIBLCB = -0.0431505      DROUT   = 0.9919348
+PSCBE1  = 6.611774E8     PSCBE2  = 3.238266E-4     PVAG    = 0
+DELTA   = 0.01           RSH     = 83.5            MOBMOD  = 1
+PRT     = 0              UTE     = -1.5            KT1     = -0.11
+KT1L    = 0              KT2     = 0.022           UA1     = 4.31E-9
+UB1     = -7.61E-18      UC1     = -5.6E-11        AT      = 3.3E4
+WL      = 0              WLN     = 1               WW      = 0
+WWN     = 1              WWL     = 0               LL      = 0
+LLN     = 1              LW      = 0               LWN     = 1
+LWL     = 0              CAPMOD  = 2               XPART   = 0.5
+CGDO    = 2.32E-10       CGSO    = 2.32E-10        CGBO    = 1E-9
+CJ      = 4.282017E-4    PB      = 0.9317787       MJ      = 0.4495867
+CJSW    = 3.034055E-10   PBSW    = 0.8             MJSW    = 0.1713852
+CJSWG   = 1.64E-10       PBSWG   = 0.8             MJSWG   = 0.1713852
+CF      = 0              PVTH0   = 0.0520855       PRDSW   = 112.8875816
+PK2     = -0.0289036     WKETA   = -0.0237483      LKETA   = 1.728324E-3
)
*
.MODEL CMOSP PMOS (                                 LEVEL   = 49
+VERSION = 3.1            TNOM    = 27              TOX     = 1.42E-8
+XJ      = 1.5E-7         NCH     = 1.7E17          VTH0    = -0.9232867
+K1      = 0.5464347      K2      = 8.119291E-3     K3      = 5.1623206
+K3B     = -0.8373484     W0      = 1.30945E-8      NLX     = 5.772187E-8
+DVT0W   = 0              DVT1W   = 0               DVT2W   = 0
+DVT0    = 2.0973823      DVT1    = 0.5356454       DVT2    = -0.1185455
+U0      = 220.5922586    UA      = 3.144939E-9     UB      = 1E-21
+UC      = -6.19354E-11   VSAT    = 1.176415E5      A0      = 0.8441929
+AGS     = 0.1447245      B0      = 1.149181E-6     B1      = 5E-6
+KETA    = -1.093365E-3   A1      = 3.467482E-4     A2      = 0.4667486
+RDSW    = 3E3            PRWG    = -0.0418549      PRWB    = -0.0212201
+WR      = 1              WINT    = 3.007497E-7     LINT    = 1.040439E-7
+XL      = 1E-7           XW      = 0               DWG     = -2.133809E-8
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+DWB     = 1.706031E-8    VOFF    = -0.0801591     NFACTOR = 0.9468597
+CIT     = 0              CDSC    = 2.4E-4         CDSCD   = 0
+CDSCB   = 0              ETA0    = 0.4060383      ETAB    = -0.0633609
+DSUB    = 1              PCLM    = 2.2703293      PDIBLC1 = 0.0279014
+PDIBLC2 = 3.201161E-3    PDIBLCB = -0.057478      DROUT   = 0.1718548
+PSCBE1  = 4.876974E9     PSCBE2  = 5E-10          PVAG    = 0
+DELTA   = 0.01           RSH     = 105.3          MOBMOD  = 1
+PRT     = 0              UTE     = -1.5           KT1     = -0.11
+KT1L    = 0              KT2     = 0.022          UA1     = 4.31E-9
+UB1     = -7.61E-18      UC1     = -5.6E-11       AT      = 3.3E4
+WL      = 0              WLN     = 1              WW      = 0
+WWN     = 1              WWL     = 0              LL      = 0
+LLN     = 1              LW      = 0              LWN     = 1
+LWL     = 0              CAPMOD  = 2              XPART   = 0.5
+CGDO    = 3.12E-10       CGSO    = 3.12E-10       CGBO    = 1E-9
+CJ      = 7.254264E-4    PB      = 0.9682229      MJ      = 0.4969013
+CJSW    = 2.496599E-10   PBSW    = 0.99           MJSW    = 0.386204
+CJSWG   = 6.4E-11        PBSWG   = 0.99           MJSWG   = 0.386204
+CF      = 0              PVTH0   = 5.98016E-3     PRDSW   = 14.8598424
+PK2     = 3.73981E-3     WKETA   = 7.286716E-4    LKETA   = -4.768569E-3
)
*
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