## Homework 3

## 1) CMOS Inverter

- a) Use HSpice to plot the transfer characteristics (output vs. input) of a CMOS inverter with  $(W/L)_n=2.4\mu m/1.2\mu m$  and  $(W/L)_p=6.0\mu m/1.2\mu m$ , respectively. Simulate your circuit for the two bipolar supply voltages of ±1.5V and ±2.5 V. For each case, deduce the voltage gain and the approximate linear output range.
- b) Compute the voltage gain from a linear equivalent circuit and compare your results with the values deduced from HSpice simulations.
- c) Load the inverter with a capacitor of 100 fF and simulate its response to a symmetrical pulsed input voltage with rail-to-rail voltage swing, a period of 50 ns and rise and fall times of 0.5 ns. Run your simulations for both ±1.5V and ±2.5 V supply rails and find the corresponding 10-90% rise and fall times of the output voltage.
- d) Repeat the above simulations for an inverter with  $(W/L)_n=1.2\mu m/0.6\mu m$  and  $(W/L)_p=3.0\mu m/0.6\mu m$ . Explain the differences.

## 2) Common-Drain Amplifier (Source Follower)

Design a common-drain amplifier that keeps the voltage gain close to unity and yields an output resistance of less than 5 k $\Omega$ . Use a p-channel device as the active gain stage and establish the Q-point current I<sub>DQ</sub> by means of a current source. The latter will also be realized by a p-channel device. The supply rails are ±2.5 V.

- a) Find the relationship between output resistance  $r_{out}$  and bias current  $I_{DQ}$ .
- b) Assume that the p-channel output stage features a (W/L) ratio of  $30\mu$ m/1.2 $\mu$ m. What is the minimum value of the bias current I<sub>DQ</sub> that guarantees r<sub>out</sub> to be less than 5 k $\Omega$ ?
- c) Compute the voltage gain in the absence of a body effect.
- d) How much voltage gain is lost (in %) if you include the body effect?
- e) Apply a sinusoidal input voltage of 1 V and use HSpice to confirm your theoretical results.
- f) What is the maximum input voltage swing (peak-to-peak) your circuit can accommodate? Define the swing limit as the voltage that causes a total harmonic distortion in excess of 1%. Use HSpice to find the answer and analyze the circuit both with and without a body effect.

## SPICE BSIM3 VERSION 3.1 PARAMETERS

MODEL							10
	fet NMOS (	TINOM	_	27	LEVEL		49 1 20E 9
+VERSION +XJ	= 3.1 = 1.5E-7	TNOM NCH		27 1.7E17	TOX VTH0		1.39E-8 0.6398186
	= 0.8857752	K2		-0.0935679	K3		22.1010569
+K1 +K3B	= 0.8857752 = -7.6711263	KZ WO		-0.0935679 1E-8	NLX		1E-9
+DVTOW	= 0	WU DVT1W		0	DVT2W		0
+DVIOW +DVT0	= 0 = 2.7950058	DVIIW DVT1		0.4085592	DVIZW DVT2		-0.1237812
+DV10 +U0	= 453.2010286			2.494433E-13	UB		1.488658E-18
+00 +UC	= 453.2010288 = 2.022743E-11	UA VSAT		1.730467E5	A0		0.5543744
+OC +AGS	= 0.1151449	B0		2.792031E-6	B1		5E-6
+KETA	= -1.371458E-3	В0 А1		0	A2		0.3560219
+RDSW	= 1.319508E3	PRWG		0.0381943	PRWB		0.0141195
+WR	= 1.319508E5	WINT		2.507126E-7	LINT		2.304464E-8
+XL	= 1 = 0	XW		0	DWG		-1.755808E-8
+DWB	= 0 = 4.946821E-8	VOFF		0			0.7910748
+CIT	= 0	CDSC		0 2.4E-4	CDSCD		0
+CDSCB	= 0	ETA0		0.0051332	ETAB		-1.252309E-3
+DSUB	= 0.1945608	PCLM		2.253484	PDIBLC1		
	= 2.440187E-3			-0.1294159	DROUT		0.6751288
+PSCBE1	= 5.348212E8	PSCBE2		3.233314E-5	PVAG		0
+DELTA	= 0.01	RSH		80.3	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
+WL +WWN	= 0	WIIN		0	LL		0
+UUN +LLN	= 1	LW		0	LWN		1
+LWL	= 0	CAPMOD		2	XPART		0.5
+LWL +CGDO	= 0 = 2.12E-10	CGSO		2.12E-10	CGBO		1E-9
+CJ	= 4.279445E-4	PB		0.9616445	MJ		0.4374524
+CJSW	= 3.492439E-10	PBSW		0.1	MJSW		0.1245165
+CJSWG	= 1.64E - 10	PBSWG		0.1	MJSWG		0.1245165
+CF	= 0	PVTH0		0.0431719	PRDSW		-30.376525
+PK2	= -0.0350028	WKETA		-0.0230093	LKETA		2.090253E-3)
1 FICZ	0.0330020	MICETH	_	0.0230093			
*							2.0002002 0,
	fet PMOS (						
.MODEL p:	fet PMOS ( = 3.1	TNOM			LEVEL	=	49
.MODEL p: +VERSION	= 3.1	TNOM NCH	=	27	LEVEL TOX	=	49 1.39E-8
.MODEL p: +VERSION +XJ	= 3.1 = 1.5E-7	NCH	=	27 1.7E17	LEVEL TOX VTH0	= =	49 1.39E-8 -0.9488171
.MODEL p: +VERSION +XJ +K1	= 3.1 = 1.5E-7 = 0.5429357	NCH K2	= = =	27 1.7E17 9.433657E-3	LEVEL TOX VTH0 K3	= =	49 1.39E-8 -0.9488171 3.2656684
.MODEL p: +VERSION +XJ +K1 +K3B	= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156	NCH K2 W0	= = =	27 1.7E17 9.433657E-3 1E-8	LEVEL TOX VTH0 K3 NLX	= = =	49 1.39E-8 -0.9488171 3.2656684 1.48542E-8
.MODEL p: +VERSION +XJ +K1 +K3B +DVTOW	= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156 = 0	NCH K2 W0 DVT1W	= = =	27 1.7E17 9.433657E-3 1E-8 0	LEVEL TOX VTH0 K3 NLX DVT2W		49 1.39E-8 -0.9488171 3.2656684 1.48542E-8 0
.MODEL p: +VERSION +XJ +K1 +K3B +DVT0W +DVT0	= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156 = 0 = 2.530444	NCH K2 W0 DVT1W DVT1		27 1.7E17 9.433657E-3 1E-8 0 0.5291909	LEVEL TOX VTH0 K3 NLX DVT2W DVT2		49 1.39E-8 -0.9488171 3.2656684 1.48542E-8 0 -0.1040273
.MODEL p: +VERSION +XJ +K1 +K3B +DVT0W +DVT0 +U0	= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156 = 0 = 2.530444 = 220.9301068	NCH K2 W0 DVT1W DVT1 UA		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9	LEVEL TOX VTH0 K3 NLX DVT2W DVT2 UB		49 1.39E-8 -0.9488171 3.2656684 1.48542E-8 0 -0.1040273 1E-21
.MODEL p: +VERSION +XJ +K1 +K3B +DVT0W +DVT0 +U0 +UC	= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156 = 0 = 2.530444 = 220.9301068 = -5.63429E-11	NCH K2 W0 DVT1W DVT1 UA VSAT		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5	LEVEL TOX VTH0 K3 NLX DVT2W DVT2 UB A0		49 1.39E-8 -0.9488171 3.2656684 1.48542E-8 0 -0.1040273 1E-21 0.9085767
.MODEL p: +VERSION +XJ +K1 +K3B +DVT0W +DVT0 +U0 +UC +AGS	= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156 = 0 = 2.530444 = 220.9301068 = -5.63429E-11 = 0.1506017	NCH K2 W0 DVT1W DVT1 UA VSAT B0		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5 9.121548E-7	LEVEL TOX VTH0 K3 NLX DVT2W DVT2 UB A0 B1		49 1.39E-8 -0.9488171 3.2656684 1.48542E-8 0 -0.1040273 1E-21 0.9085767 5E-6
.MODEL p: +VERSION +XJ +K1 +K3B +DVT0W +DVT0 +U0 +UC +AGS +KETA	= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156 = 0 = 2.530444 = 220.9301068 = -5.63429E-11 = 0.1506017 = -2.819843E-3	NCH K2 W0 DVT1W DVT1 UA VSAT B0 A1		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5 9.121548E-7 0	LEVEL TOX VTH0 K3 NLX DVT2W DVT2 UB A0 B1 A2		49 1.39E-8 -0.9488171 3.2656684 1.48542E-8 0 -0.1040273 1E-21 0.9085767 5E-6 0.3
.MODEL p: +VERSION +XJ +K1 +K3B +DVT0W +DVT0 +U0 +U0 +UC +AGS +KETA +RDSW	<pre>= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156 = 0 = 2.530444 = 220.9301068 = -5.63429E-11 = 0.1506017 = -2.819843E-3 = 3E3</pre>	NCH K2 W0 DVT1W DVT1 UA VSAT B0 A1 PRWG		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5 9.121548E-7 0 -0.0464229	LEVEL TOX VTH0 K3 NLX DVT2W DVT2 UB A0 B1 A2 PRWB		49 1.39E-8 -0.9488171 3.2656684 1.48542E-8 0 -0.1040273 1E-21 0.9085767 5E-6 0.3 -0.0398483
.MODEL p: +VERSION +XJ +K1 +K3B +DVTOW +DVTO +UO +UC +AGS +KETA +RDSW +WR	<pre>= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156 = 0 = 2.530444 = 220.9301068 = -5.63429E-11 = 0.1506017 = -2.819843E-3 = 3E3 = 1</pre>	NCH K2 W0 DVT1W DVT1 UA VSAT B0 A1 PRWG WINT		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5 9.121548E-7 0 -0.0464229 2.90101E-7	LEVEL TOX VTH0 K3 NLX DVT2W DVT2 UB A0 B1 A2 PRWB LINT		49 1.39E-8 -0.9488171 3.2656684 1.48542E-8 0 -0.1040273 1E-21 0.9085767 5E-6 0.3 -0.0398483 4.254314E-8
. MODEL p: +VERSION +XJ +K1 +K3B +DVTOW +DVTO +UO +UC +AGS +KETA +RDSW +WR +XL	<pre>= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156 = 0 = 2.530444 = 220.9301068 = -5.63429E-11 = 0.1506017 = -2.819843E-3 = 3E3 = 1 = 0</pre>	NCH K2 W0 DVT1W DVT1 UA VSAT B0 A1 PRWG		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5 9.121548E-7 0 -0.0464229 2.90101E-7 0	LEVEL TOX VTH0 K3 NLX DVT2W DVT2 UB A0 B1 A2 PRWB LINT DWG		49 1.39E-8 -0.9488171 3.2656684 1.48542E-8 0 -0.1040273 1E-21 0.9085767 5E-6 0.3 -0.0398483 4.254314E-8 -2.169468E-8
. MODEL p: +VERSION +XJ +K1 +K3B +DVT0W +DVT0 +U0 +UC +AGS +KETA +RDSW +WR +XL +XL +DWB	<pre>= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156 = 0 = 2.530444 = 220.9301068 = -5.63429E-11 = 0.1506017 = -2.819843E-3 = 3E3 = 1</pre>	NCH K2 W0 DVT1W DVT1 UA VSAT B0 A1 PRWG WINT XW		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5 9.121548E-7 0 -0.0464229 2.90101E-7	LEVEL TOX VTH0 K3 NLX DVT2W DVT2 UB A0 B1 A2 PRWB LINT DWG		49 1.39E-8 -0.9488171 3.2656684 1.48542E-8 0 -0.1040273 1E-21 0.9085767 5E-6 0.3 -0.0398483 4.254314E-8
. MODEL p: +VERSION +XJ +K1 +K3B +DVTOW +DVTO +UO +UC +AGS +KETA +RDSW +WR +XL	<pre>= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156 = 0 = 2.530444 = 220.9301068 = -5.63429E-11 = 0.1506017 = -2.819843E-3 = 3E3 = 1 = 0 = 1.788287E-8</pre>	NCH K2 W0 DVT1W DVT1 UA VSAT B0 A1 PRWG WINT XW VOFF CDSC		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5 9.121548E-7 0 -0.0464229 2.90101E-7 0 -0.0659109	LEVEL TOX VTH0 K3 NLX DVT2W DVT2 UB A0 B1 A2 PRWB LINT DWG NFACTOR CDSCD		49 1.39E-8 -0.9488171 3.2656684 1.48542E-8 0 -0.1040273 1E-21 0.9085767 5E-6 0.3 -0.0398483 4.254314E-8 -2.169468E-8 0.8188201
. MODEL p: +VERSION +XJ +K1 +K3B +DVT0W +DVT0 +U0 +UC +AGS +KETA +RDSW +WR +XL +DWB +CIT	<pre>= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156 = 0 = 2.530444 = 220.9301068 = -5.63429E-11 = 0.1506017 = -2.819843E-3 = 3E3 = 1 = 0 = 1.788287E-8 = 0</pre>	NCH K2 W0 DVT1W DVT1 UA VSAT B0 A1 PRWG WINT XW VOFF		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5 9.121548E-7 0 -0.0464229 2.90101E-7 0 -0.0659109 2.4E-4	LEVEL TOX VTH0 K3 NLX DVT2W DVT2 UB A0 B1 A2 PRWB LINT DWG NFACTOR CDSCD ETAB		49 1.39E-8 -0.9488171 3.2656684 1.48542E-8 0 -0.1040273 1E-21 0.9085767 5E-6 0.3 -0.0398483 4.254314E-8 -2.169468E-8 0.8188201 0
. MODEL p: +VERSION +XJ +K1 +K3B +DVT0W +DVT0 +U0 +UC +AGS +KETA +RDSW +WR +XL +DSW +CIT +CDSCB +DSUB	<pre>= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156 = 0 = 2.530444 = 220.9301068 = -5.63429E-11 = 0.1506017 = -2.819843E-3 = 3E3 = 1 = 0 = 1.788287E-8 = 0 = 0</pre>	NCH K2 W0 DVT1W DVT1 UA VSAT B0 A1 PRWG WINT XW VOFF CDSC ETA0 PCLM		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5 9.121548E-7 0 -0.0464229 2.90101E-7 0 -0.0659109 2.4E-4 1.380153E-3 2.0797597	LEVEL TOX VTH0 K3 NLX DVT2W DVT2 UB A0 B1 A2 PRWB LINT DWG NFACTOR CDSCD ETAB		49 1.39E-8 -0.9488171 3.2656684 1.48542E-8 0 -0.1040273 1E-21 0.9085767 5E-6 0.3 -0.0398483 4.254314E-8 -2.169468E-8 0.8188201 0 -0.0429727
. MODEL p: +VERSION +XJ +K1 +K3B +DVT0W +DVT0 +U0 +UC +AGS +KETA +RDSW +WR +XL +DWB +CIT +CDSCB +DSUB +PDIBLC2	<pre>= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156 = 0 = 2.530444 = 220.9301068 = -5.63429E-11 = 0.1506017 = -2.819843E-3 = 3E3 = 1 = 0 = 1.788287E-8 = 0 = 0 = 0 = 0.7658995</pre>	NCH K2 W0 DVT1W DVT1 UA VSAT B0 A1 PRWG WINT XW VOFF CDSC ETA0 PCLM PDIBLCB		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5 9.121548E-7 0 -0.0464229 2.90101E-7 0 -0.0659109 2.4E-4 1.380153E-3 2.0797597 -0.0437905	LEVEL TOX VTH0 K3 NLX DVT2W DVT2 UB A0 B1 A2 PRWB LINT DWG NFACTOR CDSCD ETAB PDIBLC1 DROUT		49 1.39E-8 -0.9488171 3.2656684 1.48542E-8 0 -0.1040273 1E-21 0.9085767 5E-6 0.3 -0.0398483 4.254314E-8 -2.169468E-8 0.8188201 0 -0.0429727 0.1113965 0.3065171
. MODEL p: +VERSION +XJ +K1 +K3B +DVT0W +DVT0 +U0 +UC +AGS +KETA +RDSW +WR +XL +DSW +CIT +CDSCB +DSUB	<pre>= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156 = 0 = 2.530444 = 220.9301068 = -5.63429E-11 = 0.1506017 = -2.819843E-3 = 3E3 = 1 = 0 = 1.788287E-8 = 0 = 0 = 0.7658995 = 4.521707E-3</pre>	NCH K2 W0 DVT1W DVT1 V3 SAT B0 A1 PRWG WINT XW VOFF CDSC ETA0 PCLM PDIBLCB PSCBE2		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5 9.121548E-7 0 -0.0464229 2.90101E-7 0 -0.0659109 2.4E-4 1.380153E-3 2.0797597	LEVEL TOX VTH0 K3 NLX DVT2W DVT2 UB A0 B1 A2 PRWB LINT DWG NFACTOR CDSCD ETAB PDIBLC1 DROUT PVAG		49 1.39E-8 -0.9488171 3.2656684 1.48542E-8 0 -0.1040273 1E-21 0.9085767 5E-6 0.3 -0.0398483 4.254314E-8 -2.169468E-8 0.8188201 0 -0.0429727 0.1113965
. MODEL p: +VERSION +XJ +K1 +K3B +DVT0W +DVT0 +U0 +UC +AGS +KETA +RDSW +WR +XL +DWB +CIT +CDSCB +DSUB +PDIBLC2 +PSCBE1	<pre>= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156 = 0 = 2.530444 = 220.9301068 = -5.63429E-11 = 0.1506017 = -2.819843E-3 = 3E3 = 1 = 0 = 1.788287E-8 = 0 = 0.7658995 = 4.521707E-3 = 1.25116E10</pre>	NCH K2 W0 DVT1W DVT1 UA VSAT B0 A1 PRWG WINT XW VOFF CDSC ETA0 PCLM PDIBLCB		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5 9.121548E-7 0 -0.0464229 2.90101E-7 0 -0.0659109 2.4E-4 1.380153E-3 2.0797597 -0.0437905 1.227353E-9	LEVEL TOX VTH0 K3 NLX DVT2W DVT2 UB A0 B1 A2 PRWB LINT DWG NFACTOR CDSCD ETAB PDIBLC1 DROUT		49 1.39E-8 -0.9488171 3.2656684 1.48542E-8 0 -0.1040273 1E-21 0.9085767 5E-6 0.3 -0.0398483 4.254314E-8 -2.169468E-8 0.8188201 0 -0.0429727 0.1113965 0.3065171 8.477076E-6
. MODEL p: +VERSION +XJ +K1 +K3B +DVTOW +DVTO +UO +UC +AGS +KETA +RDSW +WR +XL +DWB +CIT +CDSCB +DSUB +PDIBLC2 +PSCBE1 +DELTA	$\begin{array}{l} = 3.1 \\ = 1.5E-7 \\ = 0.5429357 \\ = -0.8567156 \\ = 0 \\ = 2.530444 \\ = 220.9301068 \\ = -5.63429E-11 \\ = 0.1506017 \\ = -2.819843E-3 \\ = 3E3 \\ = 1 \\ = 0 \\ = 1.788287E-8 \\ = 0 \\ = 0 \\ = 0.7658995 \\ = 4.521707E-3 \\ = 1.25116E10 \\ = 0.01 \end{array}$	NCH K2 W0 DVT1W UA VSAT B0 A1 PRWG A1 PRWG WINT XW VOFF CDSC ETA0 PCLM PDIBLCB PSCBE2 RSH		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5 9.121548E-7 0 -0.0464229 2.90101E-7 0 -0.0659109 2.4E-4 1.380153E-3 2.0797597 -0.0437905 1.227353E-9 104.9	LEVEL TOX VTHO K3 DVT2W DVT2 UB A0 B1 A2 PRWB LINT DWG NFACTOR CDSCD ETAB PDIBLC1 DROUT PVAG MOBMOD		49 1.39E-8 -0.9488171 3.2656684 1.48542E-8 0 -0.1040273 1E-21 0.9085767 5E-6 0.3 -0.0398483 4.254314E-8 -2.169468E-8 0.8188201 0 -0.0429727 0.1113965 0.3065171 8.477076E-6 1
. MODEL P: +VERSION +XJ +K1 +K3B +DVTOW +DVTO +UO +UC +AGS +KETA +RDSW +WR +XL +DWB +CIT +CIT +CDSCB +DSUB +PDIBLC2 +PSCBE1 +DELTA +PRT	<pre>= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156 = 0 = 2.530444 = 220.9301068 = -5.63429E-11 = 0.1506017 = -2.819843E-3 = 3E3 = 1 = 0 = 1.788287E-8 = 0 = 0.7658995 = 4.521707E-3 = 1.25116E10 = 0.01 = 0</pre>	NCH K2 W0 DVT1W DVT1 VSAT B0 A1 PRWG WINT XW VOFF CDSC ETA0 PCLM PDIBLCB PSCBE2 RSH UTE		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5 9.121548E-7 0 -0.0464229 2.90101E-7 0 -0.0659109 2.4E-4 1.380153E-3 2.0797597 -0.0437905 1.227353E-9 104.9 -1.5	LEVEL TOX VTHO K3 NLX DVT2W DVT2 UB A0 B1 A2 PRWB LINT DWG NFACTOR CDSCD ETAB PDIBLC1 DROUT PVAG MOBMOD KT1		49 1.39E-8 -0.9488171 3.2656684 1.48542E-8 0 -0.1040273 1E-21 0.9085767 5E-6 0.3 -0.0398483 4.254314E-8 -2.169468E-8 0.8188201 0 -0.0429727 0.1113965 0.3065171 8.477076E-6 1 -0.11
. MODEL P: +VERSION +XJ +K1 +K3B +DVTOW +DVTO +UO +UC +AGS +KETA +RDSW +WR +XL +DWB +CIT +CIT +CDSCB +DSUB +PDIBLC2 +PSCBE1 +DELTA +PRT +KT1L	<pre>= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156 = 0 = 2.530444 = 220.9301068 = -5.63429E-11 = 0.1506017 = -2.819843E-3 = 3E3 = 1 = 0 = 1.788287E-8 = 0 = 0.7658995 = 4.521707E-3 = 1.25116E10 = 0.01 = 0 = 0</pre>	NCH K2 W0 DVT1W DVT1 UA VSAT B0 A1 PRWG WINT XW VOFF CDSC ETA0 PCLM PDIBLCB PSCB22 RSH UTE KT2		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5 9.121548E-7 0 -0.0464229 2.90101E-7 0 -0.0659109 2.4E-4 1.380153E-3 2.0797597 -0.0437905 1.227353E-9 104.9 -1.5 0.022	LEVEL TOX VTH0 K3 NLX DVT2W DVT2 UB A0 B1 A2 PRWB LINT DWG NFACTOR CDSCD ETAB PDIBLC1 DROUT PVAG MOBMOD KT1 UA1		49 1.39E-8 -0.9488171 3.2656684 1.48542E-8 0 -0.1040273 1E-21 0.9085767 5E-6 0.3 -0.0398483 4.254314E-8 -2.169468E-8 0.8188201 0 -0.0429727 0.1113965 0.3065171 8.477076E-6 1 -0.11 4.31E-9
. MODEL p: +VERSION +XJ +K1 +K3B +DVTOW +DVTO +UC +AGS +KETA +RDSW +WR +XL +DWB +CIT +CDSCB +DSUB +PDIBLC2 +PSCBE1 +DELTA +PRT +KT1L +UB1	<pre>= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156 = 0 = 2.530444 = 220.9301068 = -5.63429E-11 = 0.1506017 = -2.819843E-3 = 3E3 = 1 = 0 = 1.788287E-8 = 0 = 0.7658995 = 4.521707E-3 = 1.25116E10 = 0.01 = 0 = 0 = 0 = -7.61E-18</pre>	NCH K2 W0 DVT1W DVT1 UA VSAT B0 A1 PRWG WINT XW VOFF CDSC ETA0 PCLM PDIBLCB PSCBE2 RSH UTE KT2 UC1		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5 9.121548E-7 0 -0.0464229 2.90101E-7 0 -0.0659109 2.4E-4 1.380153E-3 2.0797597 -0.0437905 1.227353E-9 104.9 -1.5 0.022 -5.6E-11	LEVEL TOX VTH0 K3 NLX DVT2W DVT2 UB A0 B1 A2 PRWB LINT DWG NFACTOR CDSCD ETAB PDIBLC1 DROUT PVAG MOBMOD KT1 UA1 AT		$\begin{array}{c} 49\\ 1.39E-8\\ -0.9488171\\ 3.2656684\\ 1.48542E-8\\ 0\\ -0.1040273\\ 1E-21\\ 0.9085767\\ 5E-6\\ 0.3\\ -0.0398483\\ 4.254314E-8\\ -2.169468E-8\\ 0.8188201\\ 0\\ -0.0429727\\ 0.1113965\\ 0.3065171\\ 8.477076E-6\\ 1\\ -0.11\\ 4.31E-9\\ 3.3E4 \end{array}$
. MODEL p: +VERSION +XJ +K1 +K3B +DVTOW +DVTO +UC +AGS +KETA +RDSW +WR +XL +DWB +CIT +CDSCB +DSUB +PDIBLC2 +PSCBE1 +DELTA +PRT +KT1L +UB1 +WL	<pre>= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156 = 0 = 2.530444 = 220.9301068 = -5.63429E-11 = 0.1506017 = -2.819843E-3 = 3E3 = 1 = 0 = 1.788287E-8 = 0 = 0 = 0.7658995 = 4.521707E-3 = 1.25116E10 = 0.01 = 0 = 0 = -7.61E-18 = 0</pre>	NCH K2 W0 DVT1W DVT1 UA VSAT B0 A1 PRWG WINT XW VOFF CDSC ETA0 PCIM PDIBLCB PSCBE2 RSH UTE KT2 UC1		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5 9.121548E-7 0 -0.0464229 2.90101E-7 0 -0.0659109 2.4E-4 1.380153E-3 2.0797597 -0.0437905 1.227353E-9 104.9 -1.5 0.022 -5.6E-11 1	LEVEL TOX VTH0 K3 NLX DVT2W DVT2 UB A0 B1 A2 PRWB LINT DWG NFACTOR CDSCD ETAB PDIBLC1 DROUT PVAG MOBMOD KT1 UX1 AT		49 1.39E-8 -0.9488171 3.2656684 1.48542E-8 0 -0.1040273 1E-21 0.9085767 5E-6 0.3 -0.0398483 4.254314E-8 -2.169468E-8 0.8188201 0 -0.0429727 0.1113965 0.3065171 8.477076E-6 1 -0.11 4.31E-9 3.3E4 0
. MODEL p: +VERSION +XJ +K1 +K3B +DVT0W +DVT0 +UC +AGS +KETA +RDSW +WR +XL +DWB +CIT +CDSCB +DSUB +PDIBLC2 +PSCBE1 +DELTA +PRT +KT1L +UB1 +WL +WWN	<pre>= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156 = 0 = 2.530444 = 220.9301068 = -5.63429E-11 = 0.1506017 = -2.819843E-3 = 3E3 = 1 = 0 = 1.788287E-8 = 0 = 0 = 0.7658995 = 4.521707E-3 = 1.25116E10 = 0.01 = 0 = 0 = -7.61E-18 = 0 = 1</pre>	NCH K2 W0 DVT1W DVT1 VSAT B0 A1 PRWG WINT XW VOFF CDSC ETA0 PCLM PDIBLCB PSCBE2 RSH UTE KT2 UC1 WLN WWL		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5 9.121548E-7 0 -0.0464229 2.90101E-7 0 -0.0659109 2.4E-4 1.380153E-3 2.0797597 -0.0437905 1.227353E-9 104.9 -1.5 0.022 -5.6E-11 1 0	LEVEL TOX VTH0 K3 NLX DVT2W DVT2 UB A0 B1 A2 PRWB LINT DWG NFACTOR CDSCD ETAB PDIBLC1 DROUT PVAG MOBMOD KT1 UA1 AT WW LL		$\begin{array}{c} 49\\ 1.39E-8\\ -0.9488171\\ 3.2656684\\ 1.48542E-8\\ 0\\ -0.1040273\\ 1E-21\\ 0.9085767\\ 5E-6\\ 0.3\\ -0.0398483\\ 4.254314E-8\\ -2.169468E-8\\ 0.8188201\\ 0\\ -0.0429727\\ 0.1113965\\ 0.3065171\\ 8.477076E-6\\ 1\\ -0.11\\ 4.31E-9\\ 3.3E4\\ 0\\ 0\\ \end{array}$
MODEL P: +VERSION +XJ +K1 +K3B +DVT0W +DVT0 +UC +AGS +KETA +RDSW +WR +XL +DWB +CIT +CDSCB +DSUB +PDIBLC2 +PSCBE1 +DELTA +PRT +KT1L +UB1 +WN +LLN	<pre>= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156 = 0 = 2.530444 = 220.9301068 = -5.63429E-11 = 0.1506017 = -2.819843E-3 = 3E3 = 1 = 0 = 1.788287E-8 = 0 = 0 = 0.7658995 = 4.521707E-3 = 1.25116E10 = 0 = 0 = -7.61E-18 = 0 = 1 = 1</pre>	NCH K2 W0 DVT1W DVT1 UA VSAT B0 A1 PRWG WINT XW VOFF CDSC ETA0 PCLM PCLM PCLM PDIBLCB PSCBE2 RSH UTE KT2 UC1 WLN WWL LW		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5 9.121548E-7 0 -0.0464229 2.90101E-7 0 -0.0659109 2.4E-4 1.380153E-3 2.0797597 -0.0437905 1.227353E-9 104.9 -1.5 0.022 -5.6E-11 1 0 0	LEVEL TOX VTH0 K3 NLX DVT2W DVT2 WB A0 B1 A2 PRWB LINT DWG NFACTOR CDSCD ETAB PDIBLC1 DROUT PVAG MOBMOD KT1 UA1 AT WW LL		49 1.39E-8 -0.9488171 3.2656684 1.48542E-8 0 -0.1040273 1E-21 0.9085767 5E-6 0.3 -0.0398483 4.254314E-8 -2.169468E-8 0.8188201 0 -0.0429727 0.1113965 0.3065171 8.477076E-6 1 -0.11 4.31E-9 3.3E4 0 0 1
. MODEL p: +VERSION +XJ +K1 +K3B +DVT0W +DVT0 +U0 +UC +AGS +KETA +RDSW +WR +XL +DWB +CIT +CDSCB +DSUB +PDIBLC2 +PSCBE1 +DELTA +PRT +K1L +UB1 +WL +WWN +LLN +LWL	<pre>= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156 = 0 = 2.530444 = 220.9301068 = -5.63429E-11 = 0.1506017 = -2.819843E-3 = 3E3 = 1 = 0 = 1.788287E-8 = 0 = 0.7658995 = 4.521707E-3 = 1.25116E10 = 0.01 = 0 = 0 = -7.61E-18 = 0 = 1 = 1 = 0</pre>	NCH K2 W0 DVT1W DVT1 V3 AT PSAT PRWG A1 PRWG WINT XW VOFF CDSC ETA0 PCLM PCLM PDIBLCB PSCBE2 RSH UTE KT2 UC1 WLN WWL LW CAPMOD		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5 9.121548E-7 0 -0.0464229 2.90101E-7 0 -0.0659109 2.4E-4 1.380153E-3 2.0797597 -0.0437905 1.227353E-9 104.9 -1.5 0.022 -5.6E-11 1 0 0 2	LEVEL TOX VTH0 K3 NLX DVT2W DVT2 UB A0 B1 A2 PRWB LINT DWG NFACTOR CDSCD ETAB PDIBLC1 DROUT PVAG MOBMOD KT1 UA1 AT WW LL LL LWN XPART		49 1.39E-8 -0.9488171 3.2656684 1.48542E-8 0 -0.1040273 1E-21 0.9085767 5E-6 0.3 -0.0398483 4.254314E-8 -2.169468E-8 0.8188201 0 -0.0429727 0.1113965 0.3065171 8.477076E-6 1 -0.11 4.31E-9 3.3E4 0 0 1 0.5
. MODEL P: +VERSION +XJ +K1 +K3B +DVTOW +DVTO +UC +AGS +KETA +RDSW +WR +XL +DWB +CIT +CDSCB +DSUB +PDIBLC2 +PSCBE1 +DELTA +PRT +KT1L +UB1 +WL +WN +LLN +LWL +CGDO	<pre>= 3.1 = 1.5E-7 = 0.5429357 = -0.8567156 = 0 = 2.530444 = 220.9301068 = -5.63429E-11 = 0.1506017 = -2.819843E-3 = 3E3 = 1 = 0 = 1.788287E-8 = 0 = 0.7658995 = 4.521707E-3 = 1.25116E10 = 0.01 = 0 = 0 = -7.61E-18 = 0 = 1 = 1 = 0 = 2.25E-10</pre>	NCH K2 W0 DVT1W DVT1 V3 A1 PRWG A1 PRWG WINT XW VOFF CDSC ETA0 PCLM PDIBLCB PCLM PDIBLCB PCLM UTE KT2 UTE KT2 UTE KT2 UTE KT2 UCI KT2 UCI CDSC EXAD FO EXAD FO FO FO FO FO FO FO FO FO FO FO FO FO		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5 9.121548E-7 0 -0.0464229 2.90101E-7 0 -0.0659109 2.4E-4 1.380153E-3 2.0797597 -0.0437905 1.227353E-9 104.9 -1.5 0.022 -5.6E-11 1 0 0 2.25E-10	LEVEL TOX VTH0 K3 NLX DVT2W DVT2 UB A0 B1 A2 PRWB LINT DWG NFACTOR CDSCD ETAB PDIBLC1 DROUT PVAG MOBMOD KT1 UA1 AT WW LL LWN XPART CGBO		49 1.39E-8 -0.9488171 3.2656684 1.48542E-8 0 -0.1040273 1E-21 0.9085767 5E-6 0.3 -0.0398483 4.254314E-8 -2.169468E-8 0.8188201 0 -0.0429727 0.1113965 0.3065171 8.477076E-6 1 -0.11 4.31E-9 3.3E4 0 0 1 0.5 1E-9
. MODEL P: +VERSION +XJ +K1 +K3B +DVTOW +DVTO +UC +AGS +KETA +RDSW +WR +XL +DWB +CIT +CDSCB +DSUB +PDIBLC2 +PSCBE1 +DELTA +PRT +KT1L +UB1 +WL +UB1 +LWL +LWL +CGDO +CJ	$\begin{array}{l} = 3.1 \\ = 1.5E-7 \\ = 0.5429357 \\ = -0.8567156 \\ = 0 \\ = 2.530444 \\ = 220.9301068 \\ = -5.63429E-11 \\ = 0.1506017 \\ = -2.819843E-3 \\ = 3E3 \\ = 1 \\ = 0 \\ = 1.788287E-8 \\ = 0 \\ = 0 \\ = 0.7658995 \\ = 4.521707E-3 \\ = 1.25116E10 \\ = 0 \\ = 0 \\ = 0 \\ = 0 \\ = 0 \\ = 0 \\ = 0 \\ = 1 \\ = 1 \\ = 1 \\ = 0 \\ = 1 \\ = 1 \\ = 0 \\ = 2.25E-10 \\ = 7.308538E-4 \end{array}$	NCH K2 W0 DVT1W DVT1 UA VSAT B0 A1 PRWG WINT XW VOFF CDSC ETA0 PCLM PDIBLCB PSCBE2 RSH UTE KT2 UTE KT2 ULT WLN WWL LW CAPMOD CGSO PB		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5 9.121548E-7 0 -0.0464229 2.90101E-7 0 -0.0659109 2.4E-4 1.380153E-3 2.0797597 -0.0437905 1.227353E-9 104.9 -1.5 0.022 -5.6E-11 1 0 0 2 2.25E-10 0.9416073	LEVEL TOX VTH0 K3 NLX DVT2W DVT2 UB A0 B1 A2 PRWB LINT DWG NFACTOR CDSCD ETAB PDIBLC1 DROUT PVAG MOBMOD KT1 UA1 AT WW LL LWN XPART CGBO MJ		49 1.39E-8 -0.9488171 3.2656684 1.48542E-8 0 -0.1040273 1E-21 0.9085767 5E-6 0.3 -0.0398483 4.254314E-8 -2.169468E-8 0.8188201 0 -0.0429727 0.1113965 0.3065171 8.477076E-6 1 -0.11 4.31E-9 3.3E4 0 0 1 0.5 1E-9 0.4948413
. MODEL P: +VERSION +XJ +K1 +K3B +DVTOW +DVTO +UO +UC +AGS +KETA +RDSW +WR +XL +DWB +CIT +CDSCB +DSUB +PDIBLC2 +PSCBE1 +DELTA +PRT +KT1L +UB1 +WL +UN +LIN +LIN +LIN +LIN +CGDO +CJ +CJSW	$\begin{array}{l} = 3.1 \\ = 1.5E-7 \\ = 0.5429357 \\ = -0.8567156 \\ = 0 \\ = 2.530444 \\ = 220.9301068 \\ = -5.63429E-11 \\ = 0.1506017 \\ = -2.819843E-3 \\ = 3E3 \\ = 1 \\ = 0 \\ = 1.788287E-8 \\ = 0 \\ = 0 \\ = 0 \\ = 0.7658995 \\ = 4.521707E-3 \\ = 1.25116E10 \\ = 0 \\ = 0 \\ = 0 \\ = 0 \\ = 0 \\ = 0 \\ = 0 \\ = 1 \\ = 1 \\ = 1 \\ = 0 \\ = 2.25E-10 \\ = 7.308538E-4 \\ = 2.852637E-10 \end{array}$	NCH K2 W0 DVT1W DVT1 UA VSAT B0 A1 PRWG WINT XW VOFF CDSC ETA0 PCLM PDIBLCB PSCBE2 RSH UTE KT2 UC1 WLN WWL UC1 WIN WWL LW CAPMOD CGSO PB PBSW		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5 9.121548E-7 0 -0.0464229 2.90101E-7 0 -0.0659109 2.4E-4 1.380153E-3 2.0797597 -0.0437905 1.227353E-9 104.9 -1.5 0.022 -5.6E-11 1 0 0 2 2.25E-10 0.9416073 0.99	LEVEL TOX VTH0 K3 NLX DVT2W DVT2 UB A0 B1 A2 PRWB LINT DWG NFACTOR CDSCD ETAB PDIBLC1 DROUT PVAG MOBMOD KT1 UA1 AT WW LL AT WW LL LWN XPART CGBO MJ MJSW		$\begin{array}{c} 49\\ 1.39E-8\\ -0.9488171\\ 3.2656684\\ 1.48542E-8\\ 0\\ -0.1040273\\ 1E-21\\ 0.9085767\\ 5E-6\\ 0.3\\ -0.0398483\\ 4.254314E-8\\ -2.169468E-8\\ 0.8188201\\ 0\\ -0.0429727\\ 0.1113965\\ 0.3065171\\ 8.477076E-6\\ 1\\ -0.11\\ 4.31E-9\\ 3.3E4\\ 0\\ 0\\ 1\\ 0.5\\ 1E-9\\ 0.4948413\\ 0.3001719\\ \end{array}$
. MODEL p: +VERSION +XJ +K1 +K3B +DVTOW +DVTO +UC +AGS +KETA +RDSW +WR +XL +DWB +CIT +CDSCB +DSUB +PDIBLC2 +PSCBE1 +DELTA +PRT +KT1L +UB1 +WL +UB1 +WL +LWN +LLN +LWL +CJSW +CJSWG	$\begin{array}{l} = 3.1 \\ = 1.5E-7 \\ = 0.5429357 \\ = -0.8567156 \\ = 0 \\ = 2.530444 \\ = 220.9301068 \\ = -5.63429E-11 \\ = 0.1506017 \\ = -2.819843E-3 \\ = 3E3 \\ = 1 \\ = 0 \\ = 0 \\ = 1.788287E-8 \\ = 0 \\ = 1 \\ = 1 \\ = 1 \\ = 0 \\ = 2.25E-10 \\ = 7.308538E-4 \\ = 2.852637E-10 \\ = 6.4E-11 \end{array}$	NCH K2 W0 DVT1W DVT1 UA VSAT B0 A1 PRWG WINT XW VOFF CDSC ETA0 PCLM PDIBLCB PSCB2 RSH UTE KT2 UC1 WLN WLN WLN WLN WLN UC1 WLN CAPMOD CGSO PB PSSW PBSSWG		27 1.7E17 9.433657E-3 1E-8 0 0.5291909 3.049951E-9 2E5 9.121548E-7 0 -0.0464229 2.90101E-7 0 -0.0659109 2.4E-4 1.380153E-3 2.0797597 -0.0437905 1.227353E-9 104.9 -1.5 0.022 -5.6E-11 1 0 0 2 2.25E-10 0.9416073 0.99 0.99	LEVEL TOX VTH0 K3 NLX DVT2W DVT2 UB A0 B1 A2 PRWB LINT DWG NFACTOR CDSCD ETAB PDIBLC1 DROUT PVAG MOBMOD KT1 UA1 AT WW LL LM1 AT WW LL LM1 AT WW LL LM1 AT CGBO MJ MJSW MJSWG		$\begin{array}{c} 49\\ 1.39E-8\\ -0.9488171\\ 3.2656684\\ 1.48542E-8\\ 0\\ -0.1040273\\ 1E-21\\ 0.9085767\\ 5E-6\\ 0.3\\ -0.0398483\\ 4.254314E-8\\ -2.169468E-8\\ 0.8188201\\ 0\\ -0.0429727\\ 0.1113965\\ 0.3065171\\ 8.477076E-6\\ 1\\ -0.11\\ 4.31E-9\\ 3.3E4\\ 0\\ 0\\ 1\\ 0.5\\ 1E-9\\ 0.4948413\\ 0.3001719\\ 0.3001719\\ 0.3001719\end{array}$