



ULTRA LOW NOISE PSEUDOMORPHIC HJ FET

NE321000

FEATURES

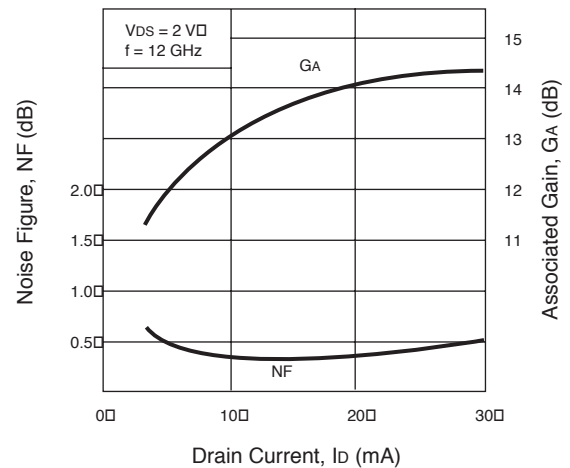
- **SUPER LOW NOISE FIGURE:**
0.35 dB Typ at $f = 12$ GHz
- **HIGH ASSOCIATED GAIN:**
13.0 dB Typ at $f = 12$ GHz
- **GATE LENGTH:** $\leq 0.2 \mu\text{m}$
- **GATE WIDTH:** $160 \mu\text{m}$

DESCRIPTION

NEC's NE321000 is a Hetero-Junction FET chip that utilizes the junction between Si-doped AlGaAs and undoped InGaAs to create high electron mobility. Its excellent low noise figure and high associated gain make it suitable for commercial, industrial and space applications.

NEC's stringent quality assurance and test procedures assure the highest reliability and performance.

NOISE FIGURE & ASSOCIATED GAIN vs.
DRAIN CURRENT



ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$)

PART NUMBER PACKAGE OUTLINE			NE321000 CHIP		
SYMBOLS	PARAMETERS AND CONDITIONS	UNITS	MIN	TYP	MAX
NF	Noise Figure, $V_{DS} = 2$ V, $I_D = 10$ mA, $f = 12$ GHz	dB		0.35	0.45
GA^1	Associated Gain, $V_{DS} = 2$ V, $I_D = 10$ mA, $f = 12$ GHz	dB	12.0	13.5	
I_{DSS}	Saturated Drain Current, $V_{DS} = 2$ V, $V_{GS} = 0$ V	mA	15	40	70
V_P	Pinch-off Voltage, $V_{DS} = 2$ V, $I_D = 100 \mu\text{A}$	V	-0.2	-0.7	-2.0
g_m	Transconductance, $V_{DS} = 2$ V, $I_D = 10 \mu\text{A}$	mS	40	55	
I_{GSO}	Gate to Source Leakage Current, $V_{GS} = -3$ V	μA		0.5	10

Note:

1. RF performance is determined by packaging and testing 10 samples per wafer. Wafer rejection criteria for standard devices is 2 rejects per 10 samples.

ABSOLUTE MAXIMUM RATINGS¹ (T_A = 25°C)

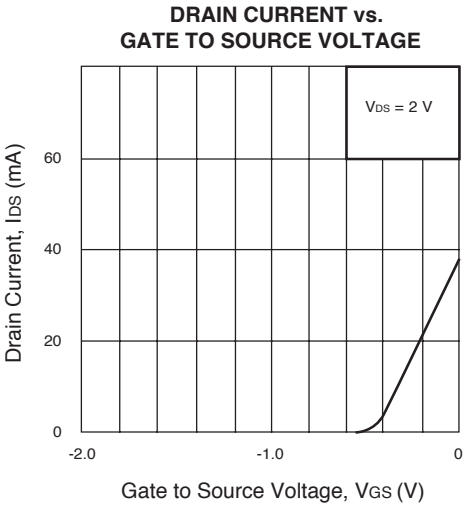
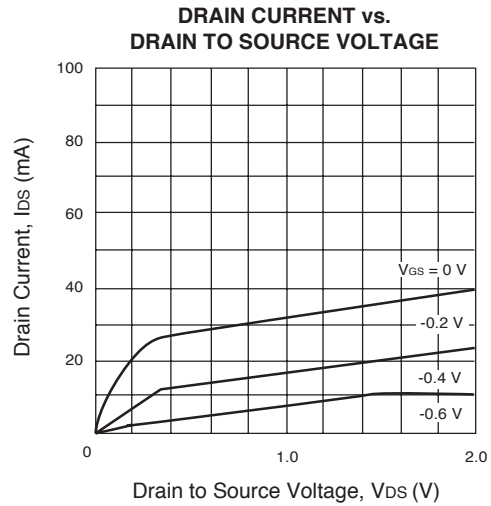
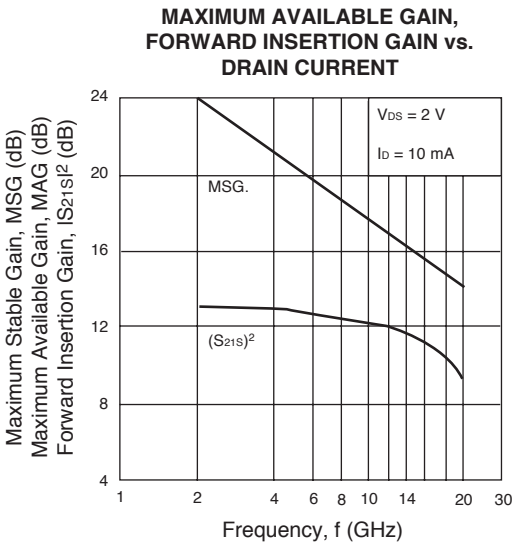
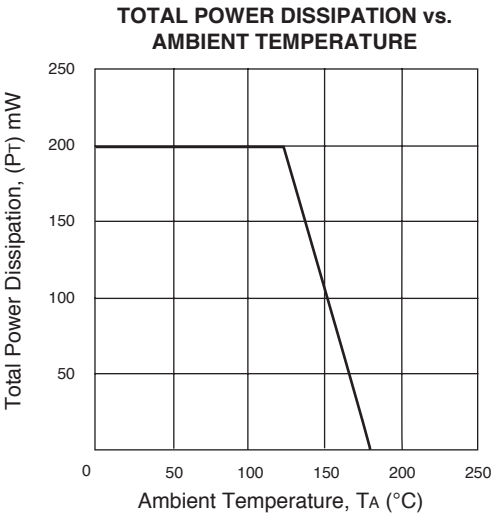
SYMBOLS	PARAMETERS	UNITS	RATINGS
V _{DS}	Drain to Source Voltage	V	4.0
V _{GS}	Gate to Source Voltage	V	-3.0
I _{DS}	Drain Current	mA	I _{DSS}
I _G	Gate Current	μA	100
P _T ²	Total Power Dissipation	mW	200
T _{CH}	Channel Temperature	°C	175
T _{STG}	Storage Temperature	°C	-65 to +175

- Notes:
1. Operation in excess of any one of these parameters may result in permanent damage.
 2. Chip mounted on Alumina heat sink.

RECOMMENDED
OPERATING CONDITIONS (T_A = 25°C)

PART NUMBER			NE321000		
SYMBOLS	PARAMETERS	UNITS	MIN	TYP	MAX
V _{DS}	Drain to Source Voltage	V	1	2	3
I _D	Drain Current	mA	5	10	15
P _{IN}	Input Power	dBm	–	–	0

TYPICAL PERFORMANCE CURVES (T_A = 25°C)



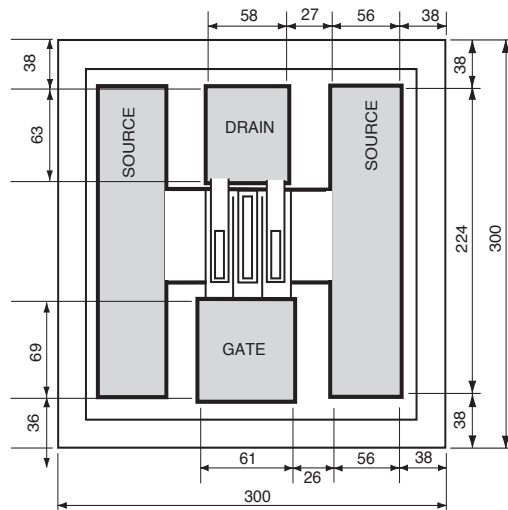
NOISE PARAMETERS

$V_{DS} = 2\text{ V}$, $I_D = 10\text{ mA}$

FREQ.(GHz)	NF MIN (dB)	G _A (dB)	Γ_{opt}		R _N /50
			MAG	ANG (DEG)	
2.0	0.21	19.5	0.94	3.7	0.31
4.0	0.22	17.6	0.87	8.2	0.31
6.0	0.24	15.9	0.82	13.3	0.32
8.0	0.26	14.6	0.77	18.8	0.32
10.0	0.28	13.5	0.73	24.8	0.32
12.0	0.31	12.7	0.69	31.4	0.31
14.0	0.38	12.1	0.67	38.4	0.31
16.0	0.45	11.6	0.64	45.9	0.30
18.0	0.52	11.3	0.63	53.9	0.29
20.0	0.59	11.2	0.62	62.4	0.28
22.0	0.66	11.1	0.61	71.4	0.27
24.0	0.72	11.2	0.62	80.8	0.25
26.0	0.79	11.2	0.63	90.8	0.23

CHIP DIMENSIONS (Units in μm)

NE321000 (CHIP)



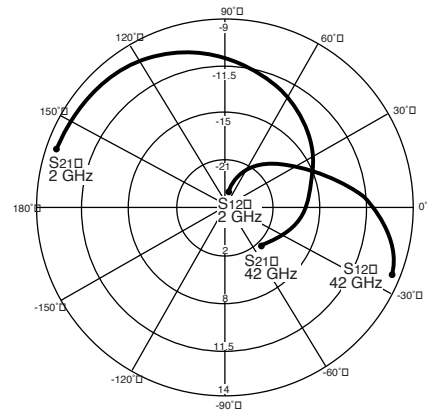
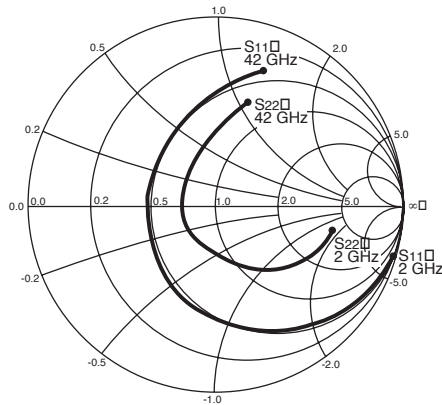
Bonding Pad Area Chip Thickness: 140 μm typical

Note: All dimensions are typical unless otherwise specified

ORDERING INFORMATION

PART NUMBER	QUALITY GRADE
NE321000	Standard (Grade D)

TYPICAL SCATTERING PARAMETERS (TA = 25°C)



VDS = 2 V, IDS = 10 mA

FREQUENCY (GHz)	S11		S21		S12		S22		K	S21 (dB)	MAG ¹ (dB)
	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG			
2.0	0.979	-15.88	4.700	161.37	0.030	0.10	0.631	-11.44	.1722	13.44	21.95
3.0	0.952	-24.04	4.658	152.38	0.045	75.46	0.618	-16.89	.2556	13.36	20.15
4.0	0.918	-32.49	4.602	143.31	0.059	70.71	0.598	-22.57	.3306	13.26	18.92
5.0	0.876	-41.18	4.536	134.13	0.072	65.92	0.574	-28.45	.4049	13.13	17.99
6.0	0.806	-53.05	4.557	123.19	0.087	59.37	0.517	-37.47	.4996	13.17	17.19
7.0	0.756	-62.14	4.400	114.52	0.097	55.24	0.492	-42.71	.5640	12.87	16.57
8.0	0.704	-71.41	4.241	105.89	0.107	51.14	0.463	-47.93	.6273	12.55	15.98
9.0	0.652	-81.35	4.086	97.18	0.116	47.15	0.428	-53.46	.6880	12.23	15.47
10.0	0.599	-91.60	3.925	88.59	0.125	43.28	0.390	-59.62	.7465	11.88	14.97
11.0	0.547	-102.52	3.757	80.01	0.132	39.42	0.351	-66.37	.8071	11.50	14.54
12.0	0.500	-113.97	3.591	71.67	0.140	36.01	0.313	-74.06	.8563	11.10	14.09
13.0	0.459	-126.08	3.418	63.45	0.146	32.77	0.279	-83.24	.9044	10.68	13.69
14.0	0.425	-138.72	3.241	55.38	0.153	29.59	0.247	-93.60	.9466	10.21	13.26
15.0	0.398	-151.46	3.069	47.70	0.160	26.77	0.221	-105.60	.9833	9.74	12.83
16.0	0.380	-164.21	2.904	40.36	0.166	24.33	0.206	-118.23	1.014	9.26	11.69
17.0	0.370	-176.46	2.750	33.25	0.174	22.07	0.195	-131.11	1.035	8.79	10.85
18.0	0.365	171.42	2.606	26.43	0.183	19.95	0.188	-144.12	1.050	8.32	10.16
19.0	0.365	159.53	2.476	19.76	0.194	17.75	0.187	-156.14	1.054	7.88	9.63
20.0	0.373	147.72	2.358	13.28	0.206	15.55	0.183	-168.03	1.055	7.45	9.16
21.0	0.388	136.67	2.252	6.48	0.220	12.96	0.182	-178.67	1.046	7.05	8.79
22.0	0.412	126.56	2.146	-0.14	0.235	10.24	0.187	163.83	1.033	6.63	8.45
23.0	0.444	117.17	2.042	-6.88	0.250	7.23	0.198	146.97	1.020	6.20	8.25
24.0	0.485	108.32	1.936	-13.88	0.268	3.56	0.226	130.10	.9985	5.74	8.59
25.0	0.532	100.27	1.819	-20.82	0.284	-0.73	0.268	114.53	.9814	5.20	8.07
26.0	0.584	93.50	1.697	-27.48	0.297	-5.09	0.320	101.53	.9648	4.59	7.57
27.0	0.636	87.38	1.584	-33.95	0.309	-9.24	0.384	91.41	.9449	3.99	7.10
28.0	0.681	81.46	1.471	-40.30	0.322	-13.52	0.449	83.86	.9259	3.35	6.60
29.0	0.723	76.25	1.361	-46.28	0.332	-17.90	0.514	77.47	.9078	2.68	6.13
30.0	0.752	71.46	1.253	-51.33	0.340	-21.67	0.571	72.94	.8978	1.96	5.67
31.0	0.771	67.12	1.158	-55.59	0.349	-24.79	0.618	69.72	.8916	1.27	5.21
32.0	0.771	62.95	1.074	-58.96	0.361	-27.19	0.654	67.81	.8963	-.42	3.68
33.0	0.760	59.66	1.003	-61.95	0.382	-29.77	0.672	65.90	.9002	.03	4.19
34.0	0.749	57.15	0.953	-63.99	0.408	-33.01	0.677	64.49	.8963	-.42	3.68
35.0	0.722	56.15	0.909	-66.52	0.428	-37.73	0.685	64.23	.8730	-.83	3.27
36.0	0.719	53.23	0.882	-68.19	0.453	-40.45	0.695	61.49	.8756	-1.09	2.89
37.0	0.686	49.28	0.870	-71.76	0.495	-46.46	0.672	57.54	.8782	-1.21	2.45
38.0	0.630	48.81	0.825	-77.56	0.504	-57.77	0.634	56.85	.8353	-1.67	2.14
39.0	0.689	49.24	0.734	-79.13	0.441	-60.27	0.683	54.33	.8086	-2.69	2.21
40.0	0.719	41.34	0.712	-79.03	0.466	-59.22	0.703	43.64	.9024	-2.95	1.84
41.0	0.729	35.32	0.694	-80.94	0.498	-62.84	0.706	32.69	.9503	-3.17	1.44
42.0	0.743	30.50	0.686	-83.24	0.534	-67.39	0.710	21.48	.9733	-3.27	1.09

Notes:

1. Gain Calculations:

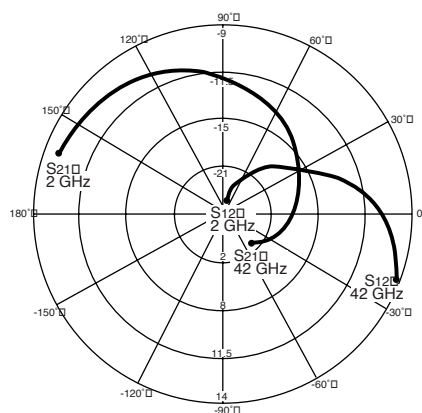
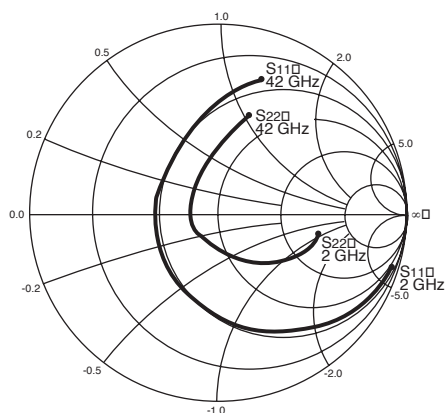
$$\text{MAG} = \frac{|S_{21}|}{|S_{12}|} \left(K \pm \sqrt{K^2 - 1} \right). \text{ When } K \leq 1, \text{ MAG is undefined and MSG values are used. } \text{MSG} = \frac{|S_{21}|}{|S_{12}|}, K = \frac{1 + |\Delta|^2 - |S_{11}|^2 - |S_{22}|^2}{2 |S_{12}| |S_{21}|}, \Delta = S_{11} S_{22} - S_{21} S_{12}$$

MAG = Maximum Available gain

MSG = Maximum Stable Gain

2. S Parameters include bond wires.

Gate : Total 1 wire(s), 1 per bond pad, (426 μm) long each wire ; 131 μm height.
 Drain : Total 1 wire(s), 1 per bond pad, (409 μm) long each wire ; 214 μm height.
 Source : Total 2 wire(s), 2 per side, (665 μm) long each wire ; 315 μm height.
 Wire : .001in (25.4 μm) Dia., Gold.

TYPICAL SCATTERING PARAMETERS (T_A = 25°C)V_{DS} = 2 V, I_{DS} = 20 mA

FREQUENCY (GHz)	S ₁₁		S ₂₁		S ₁₂		S ₂₂		K	S ₂₁ (dB)	MAG ¹ (dB)
	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG			
2.0	0.971	-17.52	5.909	159.51	0.027	80.79	0.547	-10.86	.218	15.43	23.40
3.0	0.936	-26.34	5.803	149.78	0.040	76.70	0.535	-15.95	.317	15.27	21.62
4.0	0.892	-35.36	5.665	140.08	0.052	72.46	0.515	-21.15	.410	15.06	20.37
5.0	0.840	-44.45	5.505	130.44	0.064	68.23	0.492	-26.46	.496	14.82	19.35
6.0	0.758	-56.82	5.430	119.35	0.077	62.59	0.434	-34.92	.601	14.70	18.48
7.0	0.702	-65.96	5.169	110.60	0.087	59.09	0.412	-39.33	.668	14.27	17.74
8.0	0.645	-75.18	4.915	102.02	0.096	55.73	0.387	-43.65	.734	13.83	17.09
9.0	0.591	-84.98	4.673	93.54	0.105	52.42	0.357	-48.18	.791	13.39	16.48
10.0	0.538	-95.11	4.436	85.26	0.114	49.16	0.326	-53.36	.842	12.94	15.90
11.0	0.487	-105.94	4.204	77.11	0.123	45.79	0.292	-59.13	.889	12.47	15.34
12.0	0.444	-117.44	3.984	69.25	0.131	42.69	0.259	-66.01	.929	12.01	14.83
13.0	0.407	-129.71	3.770	61.52	0.140	39.68	0.228	-74.73	.959	11.53	14.30
14.0	0.378	-142.53	3.558	53.95	0.148	36.58	0.198	-84.91	.989	11.02	13.81
15.0	0.355	-155.53	3.356	46.74	0.157	33.53	0.173	-97.54	1.013	10.52	12.60
16.0	0.342	-168.46	3.168	39.82	0.167	30.71	0.159	-111.74	1.024	10.02	11.83
17.0	0.336	179.30	2.993	33.08	0.177	27.99	0.149	-126.18	1.034	9.522	11.15
18.0	0.336	167.17	2.831	26.62	0.188	25.26	0.144	-141.58	1.039	9.039	10.57
19.0	0.338	155.65	2.684	20.28	0.201	22.47	0.145	-155.37	1.037	8.576	10.07
20.0	0.350	144.19	2.551	14.13	0.214	19.58	0.144	-169.00	1.034	8.134	9.639
21.0	0.367	133.64	2.434	7.60	0.229	16.30	0.146	175.97	1.024	7.726	9.318
22.0	0.393	124.22	2.314	1.30	0.244	13.05	0.154	159.66	1.014	7.287	9.048
23.0	0.426	115.44	2.200	-5.19	0.260	9.40	0.170	141.69	1.002	6.848	8.994
24.0	0.467	107.05	2.086	-11.91	0.278	5.31	0.203	124.84	.986	6.386	8.753
25.0	0.516	99.57	1.958	-18.67	0.293	0.68	0.250	109.99	.973	5.836	8.249
26.0	0.570	93.25	1.825	-25.00	0.306	-3.99	0.305	97.78	.961	5.225	7.755
27.0	0.623	87.32	1.705	-31.27	0.317	-8.37	0.370	88.43	.947	4.634	7.307
28.0	0.669	81.70	1.585	-37.39	0.329	-12.88	0.435	81.48	.933	4.001	6.828
29.0	0.712	76.64	1.470	-43.19	0.338	-17.40	0.500	75.71	.919	3.346	6.384
30.0	0.745	71.90	1.357	-48.18	0.346	-21.20	0.556	71.59	.910	2.652	5.935
31.0	0.763	67.71	1.257	-52.43	0.354	-24.36	0.602	68.66	.906	1.987	5.503
32.0	0.764	63.52	1.173	-55.92	0.365	-26.95	0.638	67.01	.909	1.386	5.070
33.0	0.753	59.97	1.101	-59.01	0.386	-29.64	0.655	65.37	.912	.836	4.552
34.0	0.739	57.65	1.044	-61.42	0.411	-32.78	0.658	64.16	.908	.374	4.049
35.0	0.713	56.94	0.993	-63.93	0.429	-37.54	0.665	64.34	.883	-.061	3.645
36.0	0.710	54.09	0.963	-65.83	0.454	-40.15	0.674	61.90	.884	-.328	3.266
37.0	0.676	50.40	0.943	-69.59	0.495	-45.93	0.650	58.17	.885	-.510	2.799
38.0	0.621	50.50	0.891	-75.50	0.505	-57.01	0.618	58.16	.832	-1.002	2.466
39.0	0.681	50.65	0.796	-76.38	0.444	-59.39	0.672	55.59	.808	-1.982	2.535
40.0	0.717	42.74	0.776	-77.41	0.470	-58.62	0.692	44.78	.889	-2.203	2.178
41.0	0.722	36.64	0.753	-79.78	0.502	-62.02	0.694	34.03	.940	-2.464	1.761
42.0	0.736	32.15	0.735	-82.08	0.540	-66.72	0.698	22.74	.965	-2.674	1.339

Notes:

1. Gain Calculations:

$$\text{MAG} = \frac{|S_{21}|}{|S_{12}|} (K \pm \sqrt{K^2 - 1}). \text{ When } K \leq 1, \text{ MAG is undefined and MSG values are used. } \text{MSG} = \frac{|S_{21}|}{|S_{12}|}, K = \frac{1 + |\Delta|^2 - |S_{11}|^2 - |S_{22}|^2}{2 |S_{12}| |S_{21}|}, \Delta = S_{11} S_{22} - S_{21} S_{12}$$

MAG = Maximum Available gain

MSG = Maximum Stable Gain

2. S Parameters include bond wires.

Gate : Total 1 wire(s), 1 per bond pad, (426 μm) long each wire ; 131 μm height.

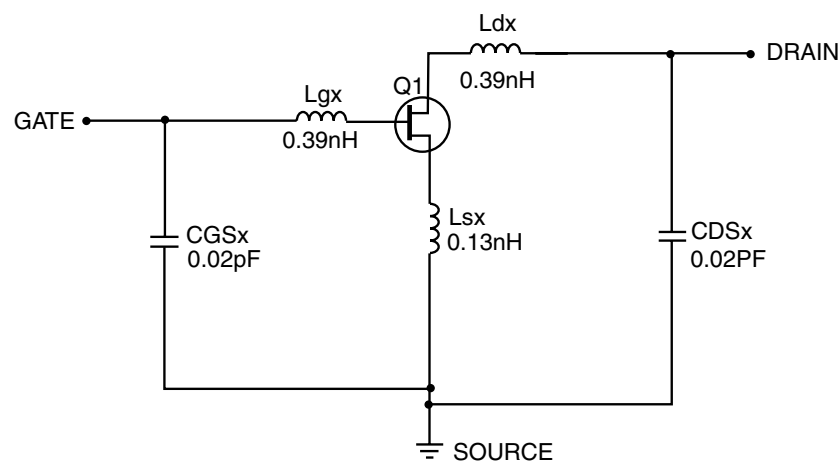
Drain : Total 1 wire(s), 1 per bond pad, (409 μm) long each wire ; 214 μm height.

Source : Total 2 wire(s), 2 per side, (665 μm) long each wire ; 315 μm height.

Wire : .001in (25.4 μm) Dia., Gold.

NE321000 NONLINEAR MODEL

SCHEMATIC



FET NONLINEAR MODEL PARAMETERS (1)

Parameters	Q1	Parameters	Q1
VTO	-0.774	RG	3
VTOSC	0	RD	3
ALPHA	8	RS	3
BETA	0.102	RGMET	0
GAMMA	0.085	KF	0
GAMMADC	0.08	AF	1
Q	2.5	TNOM	27
DELTA	0.8	XTI	3
VBI	0.6	EG	1.43
IS	1e-14	VTOTC	0
N	1	BETATCE	0
RIS	0	FFE	1
RID	0		
TAU	2e-12		
CDS	0.08e-12		
RDB	5000		
CBS	1e-9		
CGSO	0.21e-12		
CGDO	0.025e-12		
DELTA1	0.3		
DELTA2	0.2		
FC	0.5		
VBR	Infinity		

(1) Series IV Libra TOM Model

Life Support Applications
These NEC products are not intended for use in life support devices, appliances, or systems where the malfunction of these products can reasonably be expected to result in personal injury. The customers of CEL using or selling these products for use in such applications do so at their own risk and agree to fully indemnify CEL for all damages resulting from such improper use or sale.

UNITS

Parameter	Units
time	seconds
capacitance	farads
inductance	henries
resistance	ohms
voltage	volts
current	amps

MODEL RANGE
Frequency: 2 to 28 GHz
Bias: VDS = 1 V to 3 V, ID = 1 mA to 30 mA
Date: 10/99