

### FEATURES

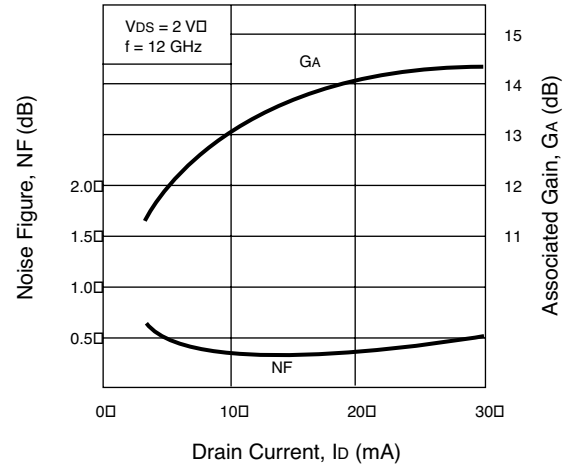
- **SUPER LOW NOISE FIGURE:**  
0.35 dB Typ at  $f = 12$  GHz
- **HIGH ASSOCIATED GAIN:**  
13.0 dB Typ at  $f = 12$  GHz
- **GATE LENGTH:**  $\leq 0.2 \mu\text{m}$
- **GATE WIDTH:**  $160 \mu\text{m}$

### DESCRIPTION

The 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
gm	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	$\mu\text{A}$		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 RATINGS<sup>1</sup>** (T<sub>A</sub> = 25°C)

SYMBOLS	PARAMETERS	UNITS	RATINGS
V <sub>DS</sub>	Drain to Source Voltage	V	4.0
V <sub>GS</sub>	Gate to Source Voltage	V	-3.0
I <sub>DS</sub>	Drain Current	mA	I <sub>DSS</sub>
I <sub>G</sub>	Gate Current	μA	100
P <sub>T</sub> <sup>2</sup>	Total Power Dissipation	mW	200
T <sub>CH</sub>	Channel Temperature	°C	175
T <sub>STG</sub>	Storage Temperature	°C	-65 to +175

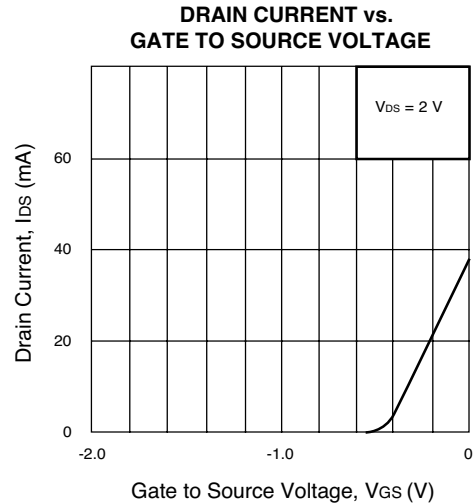
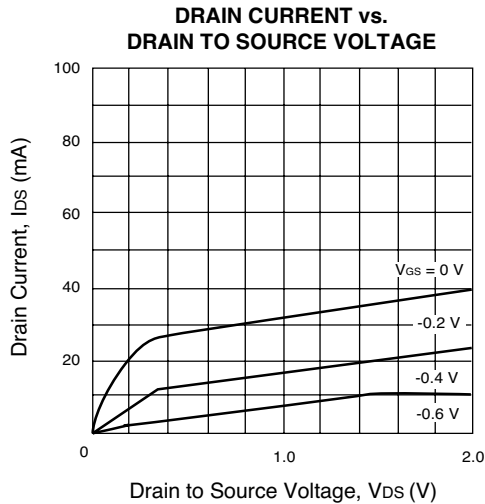
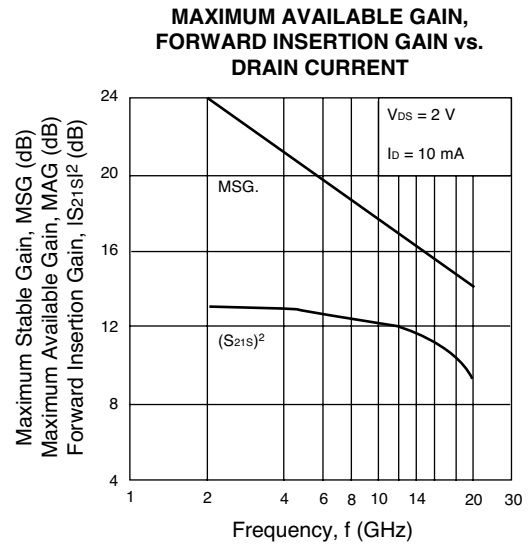
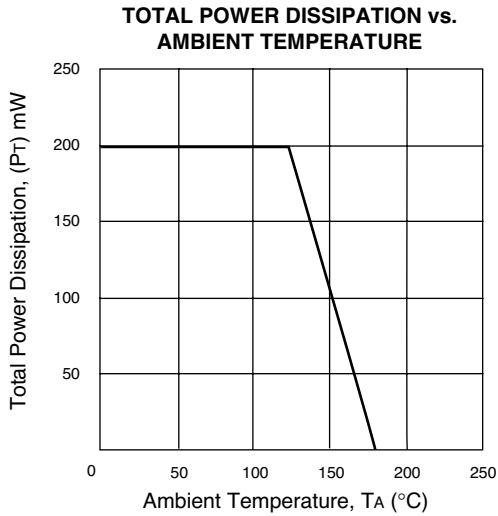
Notes:

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<sub>A</sub> = 25°C)

PART NUMBER			NE321000		
SYMBOLS	PARAMETERS	UNITS	MIN	TYP	MAX
V <sub>DS</sub>	Drain to Source Voltage	V	1	2	3
I <sub>D</sub>	Drain Current	mA	5	10	15
P <sub>IN</sub>	Input Power	dBm	-	-	0

**TYPICAL PERFORMANCE CURVES** (T<sub>A</sub> = 25°C)



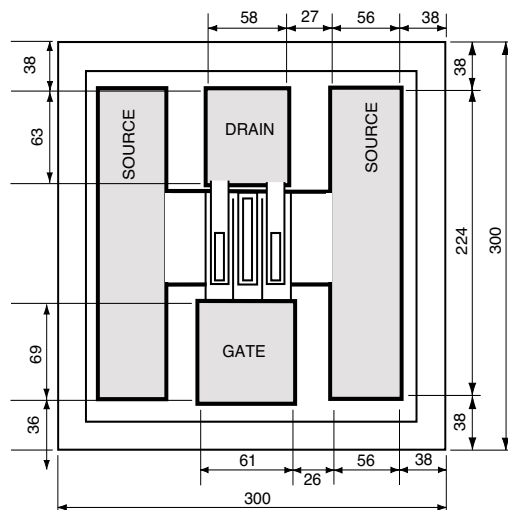
## NOISE PARAMETERS

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

FREQ.(GHz)	NF MIN (dB)	G <sub>A</sub> (dB)	Γ <sub>opt</sub>		R <sub>n</sub> /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)



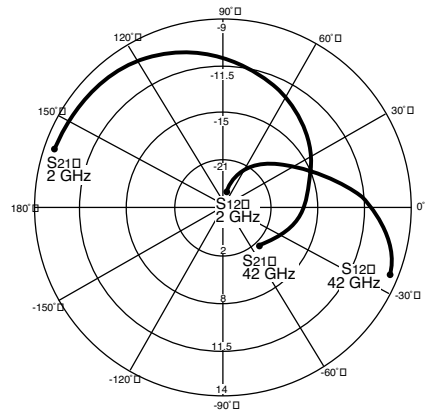
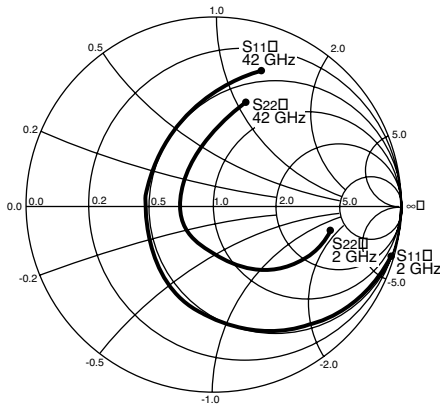
■ Bonding Pad Area      Chip Thickness: 140 μm typical

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 <sup>1</sup> (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:

$$MAG = \frac{|S_{21}|}{|S_{12}|} (K \pm \sqrt{K^2 - 1})$$

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

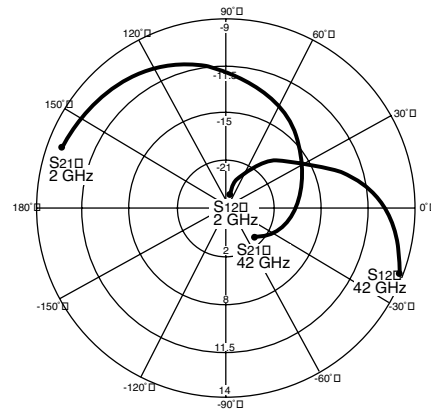
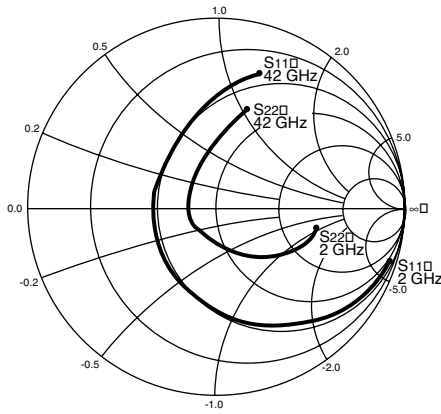
MAG = Maximum Available gain

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** (TA = 25°C)



VDS = 2 V, IDS = 20 mA

FREQUENCY (GHz)	S11		S21		S12		S22		K	S21 (dB)	MAG <sup>1</sup> (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:

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

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.

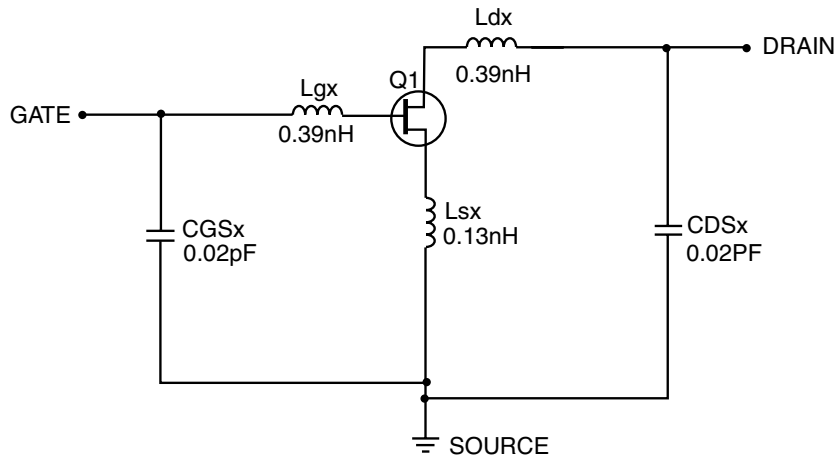
Drain : Total 1 wire(s), 1 per bond pad,(409 μm) long each wire ; 214 μm height.

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 <sup>(1)</sup>

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

UNITS

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

MODEL RANGE

Frequency: 2 to 28 GHz  
 Bias:  $V_{DS} = 1\text{ V to }3\text{ V}$ ,  $I_D = 1\text{ mA to }30\text{ mA}$   
 Date: 10/99

EXCLUSIVE NORTH AMERICAN AGENT FOR **NEC** RF, MICROWAVE & OPTOELECTRONIC SEMICONDUCTORS

**CEL** CALIFORNIA EASTERN LABORATORIES • Headquarters • 4590 Patrick Henry Drive • Santa Clara, CA 95054-1817 • (408) 988-3500 • Telex 34-6393 • FAX (408) 988-0279  
 24-Hour Fax-On-Demand: 800-390-3232 (U.S. and Canada only) • Internet: <http://WWW.CEL.COM>