

PRELIMINARY DATA SHEET

NEC

**NPN EPITAXIAL SILICON
TRANSISTOR FOR MICROWAVE
HIGH-GAIN AMPLIFICATION**

NE698M01

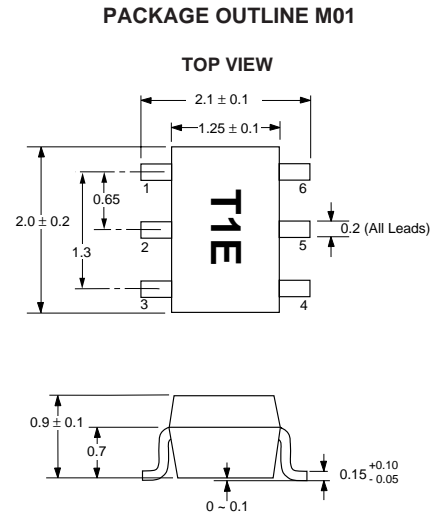
FEATURES

- **HIGH f_t :**
17 GHz TYP at 2 V, 7 mA
- **LOW NOISE FIGURE:**
NF = 1.1 dB TYP at $f = 2$ GHz, 2 V, 1 mA
- **HIGH GAIN:**
 $|S_{21E}|^2 = 15.5$ dB TYP at $f = 2$ GHz
- **6 PIN SMALL MINI MOLD PACKAGE**
- **EXCELLENT LOW VOLTAGE,
LOW CURRENT PERFORMANCE**

DESCRIPTION

The NE698M01 is an NPN high frequency silicon epitaxial transistor (NE686) encapsulated in an ultra small 6 pin SOT-363 package. Its four emitter pins decrease emitter inductance resulting in 3 dB more gain compared to conventional SOT-23 and SOT-143 devices. The NE698M01 is ideal for LNA and pre-driver applications up to 2.4 GHz where low cost, high gain, low voltage and low current are prime considerations.

OUTLINE DIMENSIONS (Units in mm)



- PIN CONNECTIONS**
- | | |
|------------|--------------|
| 1. Emitter | 4. Emitter |
| 2. Emitter | 5. Emitter |
| 3. Base | 6. Collector |

Note: Pin 3 is identified with a circle on the bottom of the package.

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

PART NUMBER PACKAGE OUTLINE			NE698M01 M01		
SYMBOLS	PARAMETERS AND CONDITIONS	UNITS	MIN	TYP	MAX
I_{CBO}	Collector Cutoff Current at $V_{CB} = 5$ V, $I_E = 0$	μA			0.1
I_{EBO}	Emitter Cutoff Current at $V_{EB} = 1$ V, $I_C = 0$	μA			0.1
h_{FE}^1	DC Current Gain at $V_{CE} = 2$ V, $I_C = 7$ mA		70		140
f_t	Gain Bandwidth Product at $V_{CE} = 2$ V, $I_C = 7$ mA, $f = 2.0$ GHz	GHz		17	
C_{RE}^2	Feedback Capacitance at $V_{CB} = 2$ V, $I_E = 0$, $f = 1$ MHz	pF		0.1	0.15
$ S_{21E} ^2$	Insertion Power Gain at $V_{CE} = 2$ V, $I_C = 7$ mA, $f = 2.0$ GHz	dB	13	15.5	
NF	Noise Figure at $V_{CE} = 2$ V, $I_C = 1$ mA, $f = 2.0$ GHz	dB		1.1	1.8

Notes:

1. Pulsed measurement, pulse width ≤ 350 μs , duty cycle ≤ 2 %.
2. The emitter terminal should be connected to the ground terminal of the 3 terminal capacitance bridge.

ABSOLUTE MAXIMUM RATINGS¹ ($T_A = 25^\circ\text{C}$)

SYMBOLS	PARAMETERS	UNITS	RATINGS
V _{CB0}	Collector to Base Voltage	V	5
V _{CE0}	Collector to Emitter Voltage	V	3
V _{EB0}	Emitter to Base Voltage	V	2
I _c	Collector Current	mA	10
P _T	Total Power Dissipation	mW	30
T _J	Junction Temperature	°C	150
T _{STG}	Storage Temperature	°C	-65 to +150

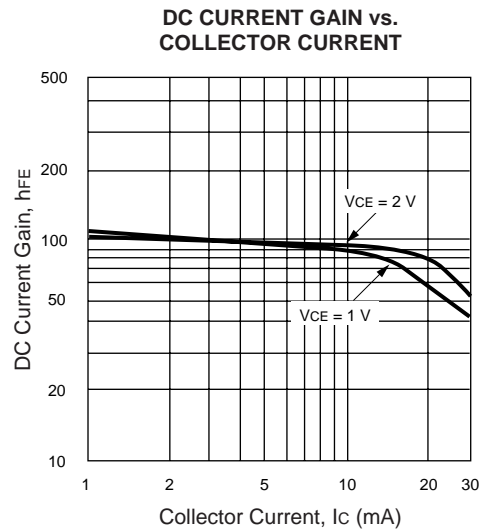
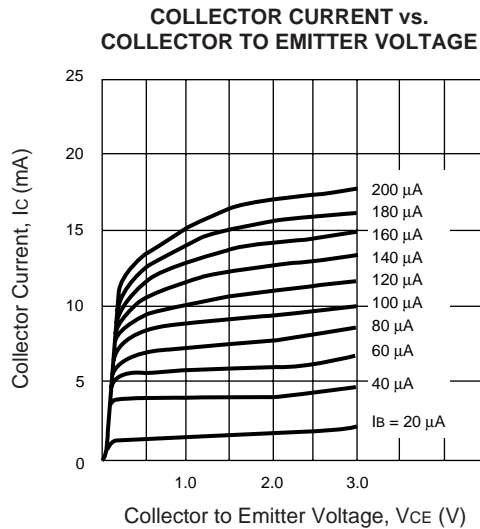
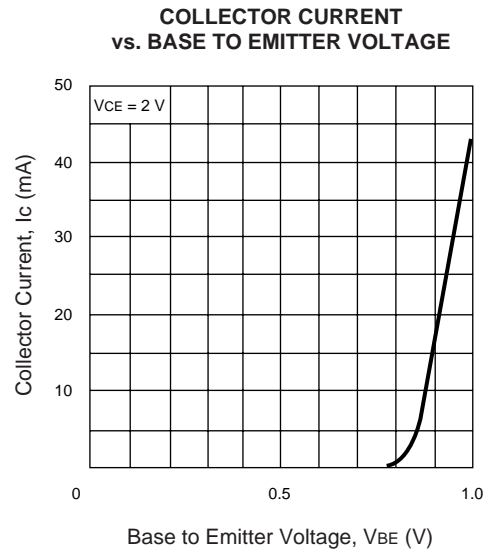
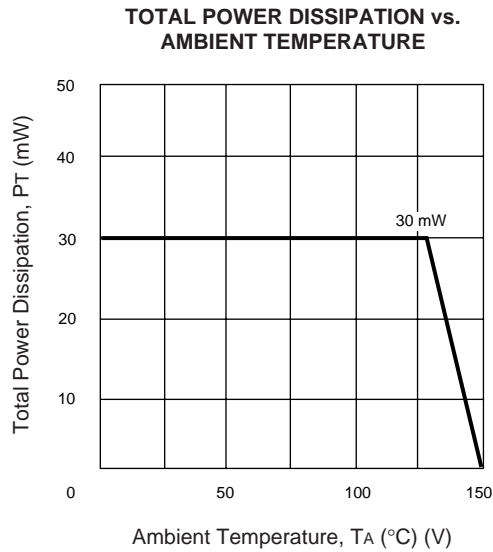
Notes:

1. Operation in excess of any one of these parameters may result in permanent damage.

ORDERING INFORMATION

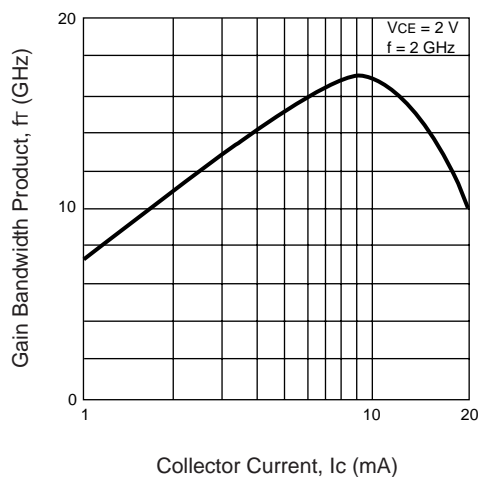
PART NUMBER	ORDER MULTIPLE	PACKAGING
NE698M01-T1	3000	Tape & Reel

TYPICAL PERFORMANCE CURVES ($T_A = 25^\circ\text{C}$)

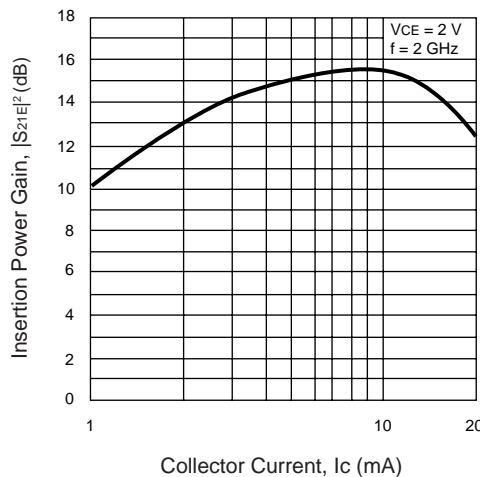


TYPICAL PERFORMANCE CURVES ($T_A = 25^\circ\text{C}$)

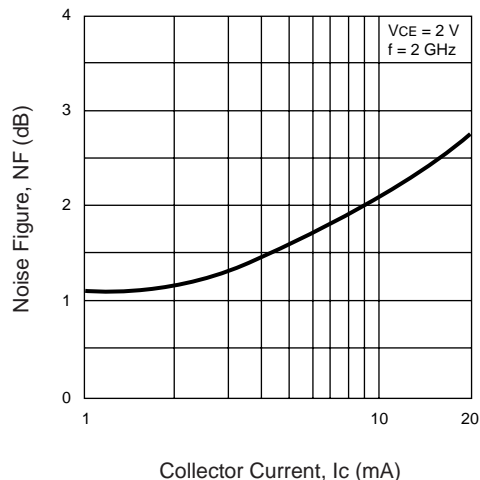
GAIN BANDWIDTH PRODUCT vs. I_c CHARACTERISTICS



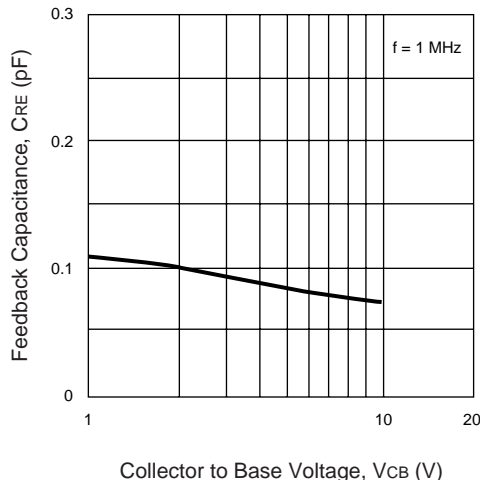
INSERTION POWER GAIN vs. I_c CHARACTERISTICS



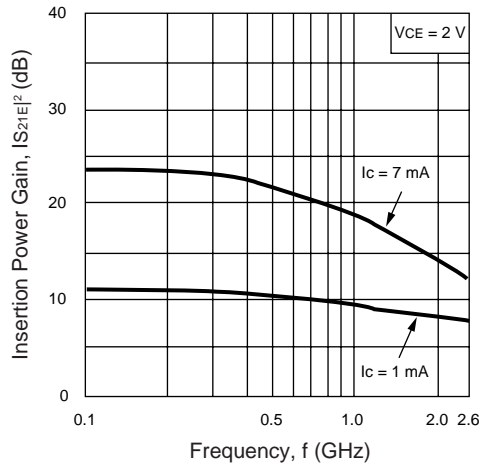
NOISE FIGURE vs. I_c CHARACTERISTICS



FEEDBACK CAPACITANCE vs. COLLECTOR TO BASE VOLTAGE



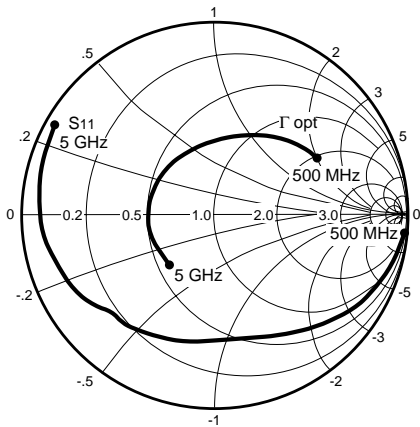
INSERTION POWER GAIN vs. FREQUENCY CHARACTERISTICS



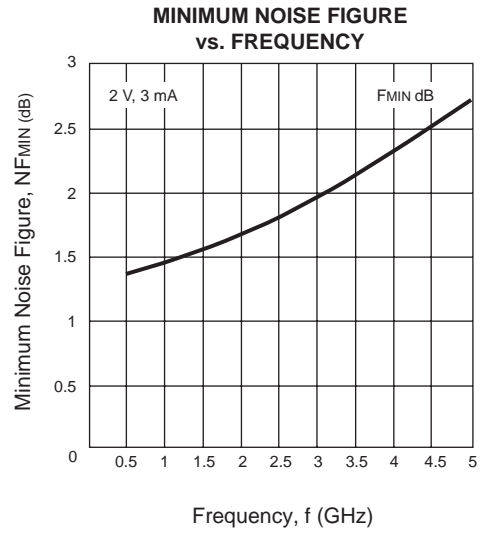
TYPICAL NOISE PARAMETERS ($T_A = 25^\circ\text{C}$)

FREQ. (GHz)	NF _{OPT} (dB)	G _A (dB)	Γ_{OPT}		Rn/50
			MAG	ANG	
VCE = 2 V, IC = 3 mA					
0.50	1.37	22	0.61	27	0.94
1.00	1.45	19	0.58	37	0.49
1.50	1.56	16.6	0.55	45	0.67
2.00	1.67	14.6	0.51	53	0.56
2.50	1.80	13.2	0.47	62	0.45
3.00	1.95	12.2	0.40	82	0.34
4.00	2.30	10.9	0.34	159	0.14
5.00	2.70	10.2	0.34	-134	0.31

TYPICAL OPTIMUM NOISE MATCH (Γ_{OPT})



(2 V, 3 mA)



TYPICAL SCATTERING PARAMETERS (T_A = 25°C)

VCE = 2 V, I_c = 1 mA

FREQUENCY f (MHz)	S ₁₁		S ₂₁		S ₁₂		S ₂₂		K	MAG ¹ (dB)
	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG		
100	0.963	-3.9	2.863	171.7	0.006	82.8	0.987	-2.7	0.21	26.7
250	0.962	-10.0	2.880	167.7	0.015	80.1	0.989	-8.2	0.11	22.8
400	0.953	-16.1	2.893	161.3	0.024	75.5	0.984	-13.0	0.12	20.8
600	0.934	-24.2	2.886	152.6	0.035	68.8	0.973	-19.5	0.16	19.2
800	0.907	-32.4	2.893	143.7	0.045	61.8	0.957	-26.0	0.21	18.1
1000	0.874	-40.6	2.852	134.7	0.054	55.1	0.938	-32.5	0.27	17.3
1200	0.838	-49.2	2.823	126.0	0.061	48.8	0.919	-39.0	0.31	16.7
1400	0.799	-57.6	2.758	117.5	0.066	42.6	0.897	-45.5	0.37	16.2
1600	0.758	-66.2	2.685	108.9	0.070	36.6	0.875	-52.0	0.43	15.9
1800	0.715	-75.3	2.629	100.5	0.071	31.1	0.853	-58.4	0.50	15.7
2000	0.668	-84.6	2.573	92.0	0.071	26.1	0.834	-64.7	0.58	15.6
2500	0.587	-107.1	2.279	72.5	0.063	17.7	0.797	-80.0	0.84	15.6
3000	0.533	-131.1	2.035	54.6	0.050	19.5	0.780	-94.4	1.23	13.2
3500	0.518	-154.4	1.772	38.0	0.042	38.7	0.785	-107.6	1.56	11.9
4000	0.532	-175.9	1.534	23.4	0.052	63.3	0.800	-119.2	1.25	11.7
4500	0.561	165.6	1.324	10.7	0.077	72.0	0.821	-129.3	0.83	12.3
5000	0.592	149.7	1.146	-0.5	0.108	71.1	0.841	-138.1	0.58	10.3

Note:

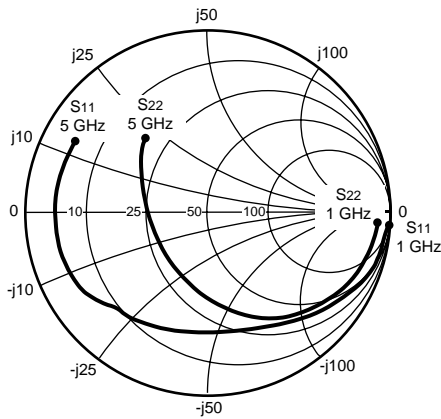
1. Gain Calculations:

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

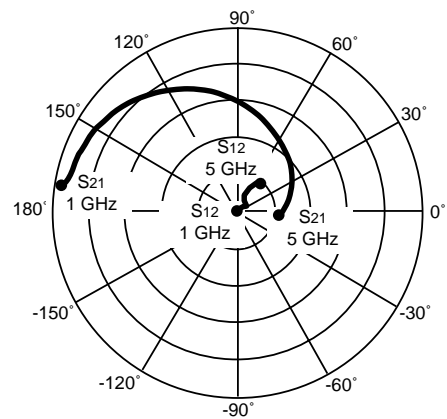
MAG = Maximum Available Gain

MSG = Maximum Stable Gain

TYPICAL SCATTERING PARAMETERS (TA = 25°C)



Coordinates in Ohms
Frequency in GHz
(VCE = 2 V, Ic = 3 mA)



VCE = 2 V, Ic = 3 mA

FREQUENCY f (MHz)	S11		S21		S12		S22		K	MAG ¹ (dB)
	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG		
100	0.910	-5.49	7.711	170.42	0.006	85.31	0.983	-4.58	0.15	31.2
200	0.903	-12.15	7.507	165.89	0.012	79.32	0.975	-8.86	0.15	28.0
300	0.886	-18.46	7.391	159.88	0.017	74.51	0.962	-13.10	0.19	26.3
400	0.867	-23.84	7.277	153.86	0.022	71.17	0.949	-17.19	0.21	25.1
500	0.844	-29.82	7.211	148.01	0.027	67.27	0.932	-21.20	0.24	24.2
600	0.818	-35.35	7.024	142.43	0.031	63.60	0.913	-24.97	0.28	23.5
700	0.789	-40.72	6.842	136.76	0.035	59.99	0.893	-28.57	0.33	22.9
800	0.758	-46.19	6.679	131.59	0.038	56.72	0.873	-31.93	0.37	22.4
900	0.727	-51.33	6.479	126.49	0.041	53.71	0.853	-35.20	0.41	21.9
1000	0.696	-56.23	6.281	121.67	0.044	51.05	0.833	-38.24	0.45	21.6
1200	0.632	-66.19	5.923	112.11	0.047	46.49	0.796	-44.05	0.54	21.0
1400	0.573	-75.35	5.541	103.48	0.050	43.02	0.763	-49.33	0.64	20.5
1600	0.519	-84.27	5.162	95.39	0.051	40.54	0.735	-54.29	0.74	20.1
1800	0.465	-93.54	4.858	87.66	0.051	39.26	0.711	-59.16	0.85	19.8
2000	0.421	-102.59	4.554	80.30	0.051	38.93	0.692	-63.82	0.96	19.5
2200	0.387	-112.30	4.244	73.46	0.051	39.56	0.679	-68.35	1.06	17.7
2400	0.355	-122.55	3.999	66.73	0.051	41.72	0.667	-73.12	1.16	16.5
2600	0.331	-133.20	3.771	60.20	0.051	44.53	0.659	-77.85	1.25	15.7
2800	0.317	-144.52	3.554	53.94	0.052	48.11	0.656	-82.78	1.30	15.1
3000	0.309	-156.20	3.363	47.78	0.054	52.26	0.655	-87.66	1.31	14.6
3500	0.328	177.03	2.911	33.02	0.065	60.65	0.668	-100.67	1.19	13.9
4000	0.383	156.43	2.518	19.22	0.082	64.68	0.692	-113.87	0.98	14.9
4500	0.451	142.11	2.167	6.57	0.104	64.38	0.723	-126.63	0.77	13.2
5000	0.527	130.35	1.864	-4.78	0.126	61.60	0.737	-136.90	0.64	11.7

Note:

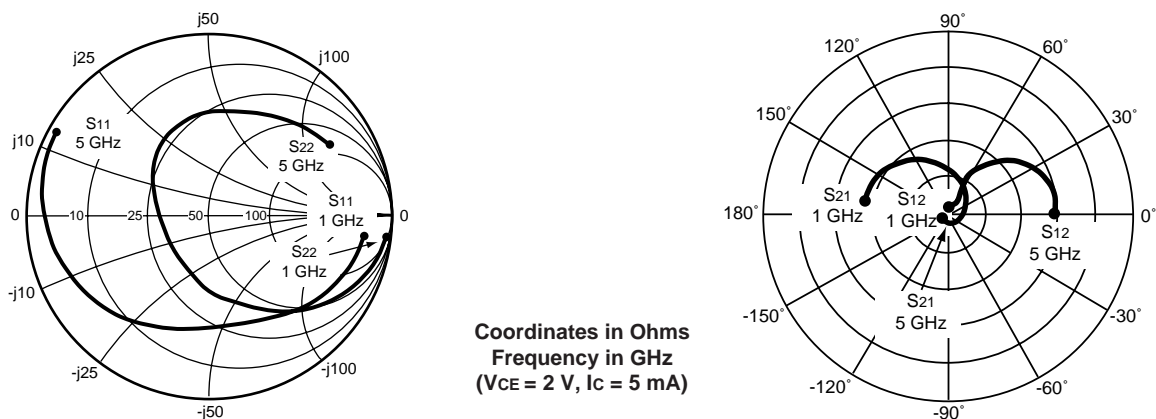
1. Gain Calculations:

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

MAG = Maximum Available Gain

MSG = Maximum Stable Gain

TYPICAL SCATTERING PARAMETERS (T_A = 25°C)



V_{CE} = 2 V, I_c = 5 mA

FREQUENCY f (MHz)	S ₁₁		S ₂₁		S ₁₂		S ₂₂		K	MAG ¹ (dB)
	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG		
100	0.852	-6.7	11.171	169.3	0.006	80.8	0.969	-4.3	0.29	32.8
250	0.828	-18.7	10.993	159.7	20.014	76.4	0.954	-12.3	0.21	28.9
400	0.786	-29.4	10.602	149.3	0.021	69.7	0.922	-19.1	0.27	27.0
600	0.713	-42.9	9.916	136.3	0.029	62.0	0.871	-27.3	0.37	25.3
800	0.629	-55.3	9.125	124.3	0.035	55.7	0.816	-34.3	0.48	24.1
1000	0.548	-66.7	8.319	113.7	0.039	51.0	0.765	-40.4	0.59	23.3
1200	0.478	-77.8	7.580	104.1	0.042	47.9	0.722	-45.9	0.70	22.5
1400	0.415	-88.4	6.906	95.6	0.044	45.9	0.686	-50.9	0.82	21.9
1600	0.364	-99.1	6.311	87.7	0.046	44.9	0.658	-55.9	0.93	21.4
1800	0.321	-110.6	5.807	80.3	0.047	45.2	0.636	-60.8	1.03	19.9
2000	0.289	-122.1	5.355	73.5	0.048	46.0	0.621	-65.7	1.12	18.4
2500	0.253	-151.7	4.432	57.8	0.052	51.3	0.604	-78.2	1.26	16.2
3000	0.266	-177.8	3.752	43.6	0.060	57.1	0.610	-90.8	1.25	15.0
3500	0.305	163.3	3.214	30.5	0.072	61.1	0.634	-103.1	1.12	14.4
4000	0.355	149.1	2.781	18.4	0.088	62.7	0.665	-114.1	0.95	15.0
4500	0.406	138.1	2.426	7.1	0.108	61.9	0.701	-123.7	0.78	13.5
5000	0.451	128.3	2.135	-3.3	0.130	59.6	0.735	-132.1	0.63	12.2

Note:

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

TYPICAL SCATTERING PARAMETERS (T_A = 25°C)

VCE = 2 V, Ic = 7 mA

FREQUENCY f (MHz)	S ₁₁		S ₂₁		S ₁₂		S ₂₂		K	MAG ¹ (dB)
	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG		
100	0.803	-8.4	14.546	168.7	0.006	81.2	0.965	-5.5	0.27	34.0
250	0.776	-22.1	13.446	157.1	0.014	75.0	0.942	-13.4	0.25	30.0
400	0.718	-34.6	12.779	145.1	0.020	67.6	0.898	-20.6	0.33	28.0
600	0.629	-49.7	11.594	131.0	0.027	60.5	0.834	-28.6	0.45	26.3
800	0.538	-63.2	10.364	118.7	0.032	55.3	0.773	-35.2	0.58	25.1
1000	0.457	-75.5	9.221	108.2	0.036	51.7	0.721	-40.6	0.71	24.1
1200	0.388	-87.6	8.246	98.8	0.038	49.9	0.679	-45.5	0.83	23.3
1400	0.332	-99.4	7.407	90.6	0.040	49.3	0.647	-50.1	0.95	22.7
1600	0.289	-111.4	6.694	83.1	0.042	49.7	0.623	-54.6	1.05	20.7
1800	0.255	-124.4	6.100	76.2	0.044	50.9	0.606	-59.3	1.14	19.2
2000	0.234	-137.5	5.591	69.7	0.046	52.3	0.595	-64.1	1.20	18.1
2500	0.227	-168.7	4.593	54.6	0.053	57.1	0.585	-76.6	1.26	16.3
3000	0.258	168.0	3.869	40.9	0.064	61.1	0.598	-89.6	1.20	15.1
3500	0.305	152.0	3.304	28.2	0.077	63.0	0.624	-102.0	1.07	14.7
4000	0.359	140.6	2.856	16.3	0.094	63.0	0.658	-113.2	0.91	14.8
4500	0.408	131.3	2.491	5.4	0.114	61.2	0.695	-123.0	0.75	13.4
5000	0.453	122.8	2.191	-4.9	0.135	58.4	0.730	-131.5	0.62	12.1

Note:

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

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>

DATA SUBJECT TO CHANGE WITHOUT NOTICE



PRINTED IN USA ON RECYCLED PAPER -10/98