



# NEC's MEDIUM POWER NPN SILICON HIGH FREQUENCY TRANSISTOR

## NE664M04

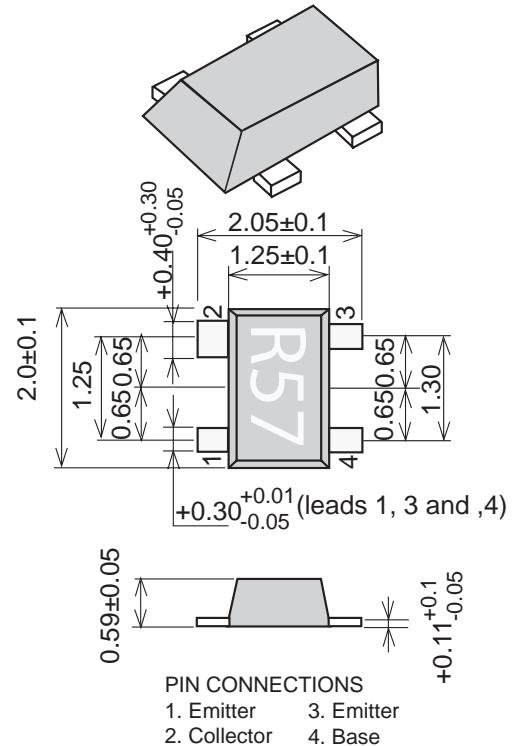
### FEATURES

- **HIGH GAIN BANDWIDTH:**  
 $f_T = 20 \text{ GHz}$
- **HIGH OUTPUT POWER:**  
 $P_{1\text{dB}} = 26 \text{ dBm}$  at 1.8 GHz
- **HIGH LINEAR GAIN:**  
 $G_L = 12 \text{ dB}$  at 1.8 GHz
- **LOW PROFILE M04 PACKAGE:**  
SOT-343 footprint, with a height of only 0.59 mm  
Flat lead style for better RF performance

### DESCRIPTION

NEC's NE664M04 is fabricated using NEC's state-of-the-art UHS0 25 GHz  $f_T$  wafer process. With a transition frequency of 20 GHz, the NE664M04 is usable in applications from 100 MHz to over 3 GHz. The NE664M04 provides  $P_{1\text{dB}}$  of 26 dBm, even with low voltage and low current, making this device an excellent choice for the output or driver stage for mobile or fixed wireless applications.

The NE664M04 is housed in NEC's low profile/flat lead style "M04" package



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

PART NUMBER PACKAGE OUTLINE EIAJ <sup>3</sup> REGISTRATION NUMBER			NE664M04 M04 2SC5754			
	SYMBOLS	PARAMETERS AND CONDITIONS	UNITS	MIN	TYP	MAX
DC	$I_{CBO}$	Collector Cutoff Current at $V_{CB} = 5 \text{ V}$ , $I_E = 0$	nA			1000
	$I_{EBO}$	Emitter Cutoff Current at $V_{EB} = 1 \text{ V}$ , $I_C = 0$	nA			1000
	$h_{FE}$	DC Current <sup>1</sup> Gain at $V_{CE} = 3 \text{ V}$ , $I_C = 100 \text{ mA}$		40	60	100
RF	$P_{1\text{dB}}$	Output Power at 1 dB compression point at $V_{CE} = 3.6 \text{ V}$ , $I_{CQ} = 4 \text{ mA}$ , $f = 1.8 \text{ GHz}$ , $P_{in} = 15 \text{ dBm}$ , 1/2 Duty Cycle	dBm		26.0	
	$G_L$	Linear Gain at $V_{CE} = 3.6 \text{ V}$ , $I_{CQ} = 20 \text{ mA}$ , $f = 1.8 \text{ GHz}$ , $P_{in} = 0 \text{ dBm}$ , 1/2 Duty Cycle	dB		12.0	
	MAG	Maximum Available Power Gain <sup>4</sup> at $V_{CE} = 3 \text{ V}$ , $I_C = 100 \text{ mA}$ , $f = 2 \text{ GHz}$	dBm		12.0	
	$ S_{21E} ^2$	Insertion Power Gain at $V_{CE} = 3 \text{ V}$ , $I_C = 100 \text{ mA}$ , $f = 2 \text{ GHz}$	dB	5.0	6.5	
	$\eta_c$	Collector Efficiency, 3.6 V, $I_{CQ} = 4 \text{ mA}$ , $f = 1.8 \text{ GHz}$ , $P_{in} = 15 \text{ dBm}$ , 1/2 Duty Cycle	%		60	
	$f_T$	Gain Bandwidth at $V_{CE} = 3 \text{ V}$ , $I_C = 100 \text{ mA}$ , $f = 0.5 \text{ GHz}$	GHz	16	20	
	$C_{re}$	Feedback Capacitance <sup>2</sup> at $V_{CB} = 3 \text{ V}$ , $I_C = 0$ , $f = 1 \text{ MHz}$	pF		1.0	1.5

Notes:

1. Pulsed measurement, pulse width  $\leq 350 \mu\text{s}$ , duty cycle  $\leq 2 \%$ .
2. Collector to Base capacitance measured by capacitance meter(automatic balance bridge method) when emitter pin is connected to the guard pin of capacitance meter.
3. Electronic Industrail Association of Japan

$$4. \text{MAG} = \frac{|S_{21}|}{|S_{12}|} (K - \sqrt{K^2 - 1})$$

**ABSOLUTE MAXIMUM RATINGS<sup>1</sup>** ( $T_A = 25^\circ\text{C}$ )

SYMBOLS	PARAMETERS	UNITS	RATINGS
V <sub>CB0</sub>	Collector to Base Voltage	V	13
V <sub>CE0</sub>	Collector to Emitter Voltage	V	5.0
V <sub>EB0</sub>	Emitter to Base Voltage	V	1.5
I <sub>C</sub>	Collector Current	mA	500
P <sub>T</sub>	Total Power Dissipation <sup>2</sup>	mW	735
T <sub>J</sub>	Junction Temperature	°C	150
T <sub>STG</sub>	Storage Temperature	°C	-65 to +150

Note:

1. Operation in excess of any one of these parameters may result in permanent damage.
2. Mounted on 38 x 38 mm, t = 0.4 mm polyimide PCB.

**ORDERING INFORMATION**

PART NUMBER	QUANTITY
NE664M04-T2	3k pcs./reel

**THERMAL RESISTANCE**

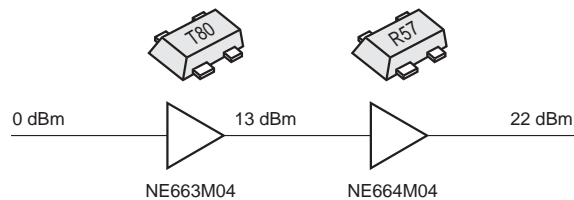
SYMBOLS	PARAMETERS	UNITS	RATINGS
R <sub>th j-a1</sub>	Junction to Ambient Resistance <sup>1</sup>	°C/W	170
R <sub>th j-a2</sub>	Junction to Ambient Resistance <sup>2</sup>	°C/W	570

Note:

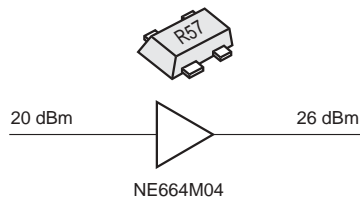
1. Mounted on 38 x 38 mm, t = 0.4 mm polyimide PCB.
2. Stand alone device in free air.

**APPLICATIONS**

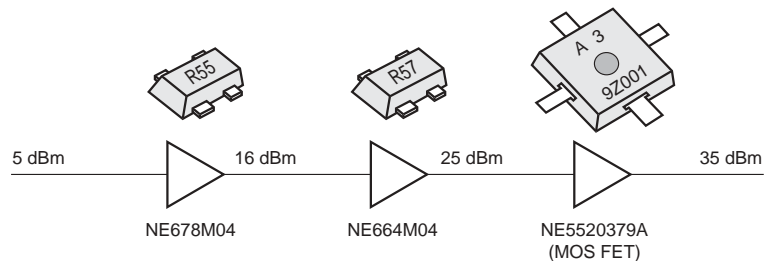
Bluetooth Power Class 1  
f = 2.4 GHz



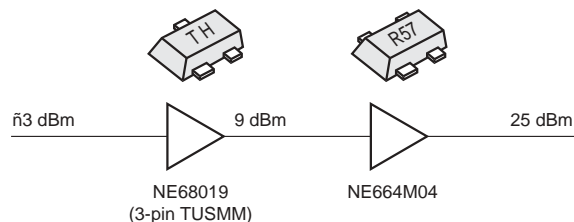
SS Cordless Phone  
f = 2.4 GHz



DCS1800 (GSM1800) Cellular Phone  
f = 1.8 GHz

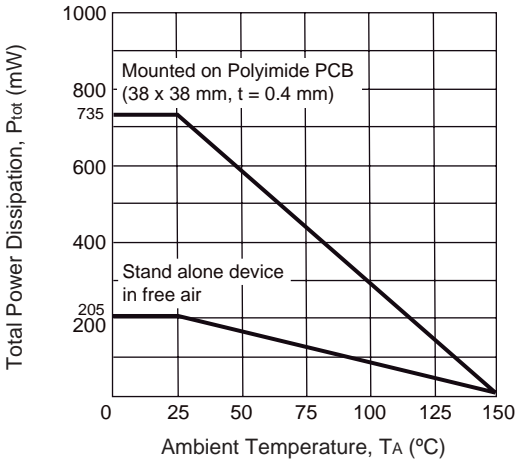


Cordless Phone  
f = 0.9 GHz

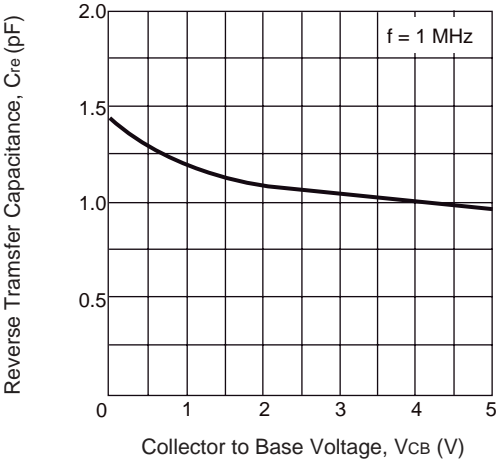


TYPICAL PERFORMANCE CURVES (TA = 25°C)

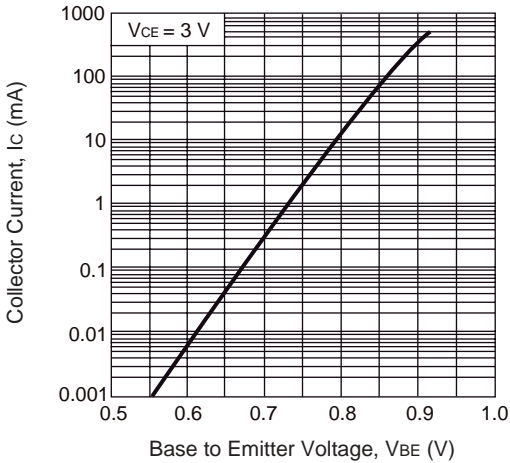
TOTAL POWER DISSIPATION vs. AMBIENT TEMPERATURE



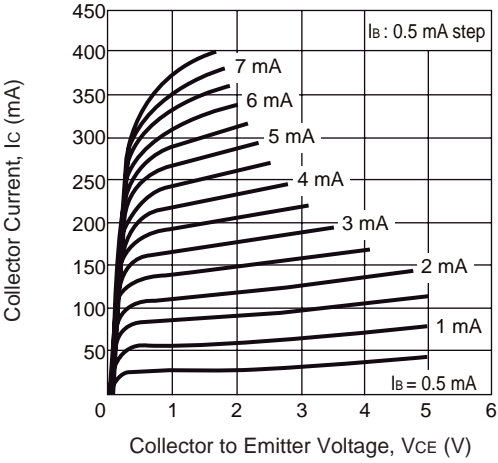
REVERSE TRANSFER CAPACITANCE vs. COLLECTOR TO BASE VOLTAGE



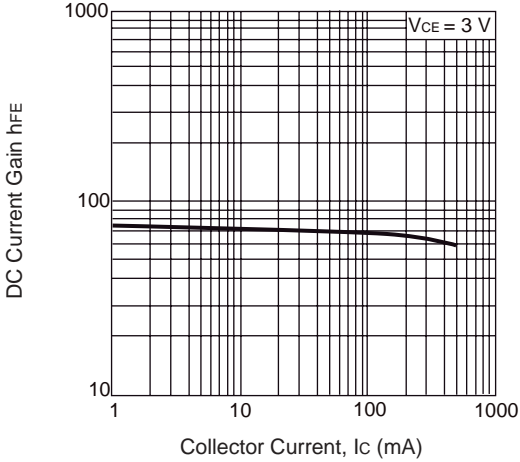
COLLECTOR CURRENT vs. BASE TO EMITTER VOLTAGE

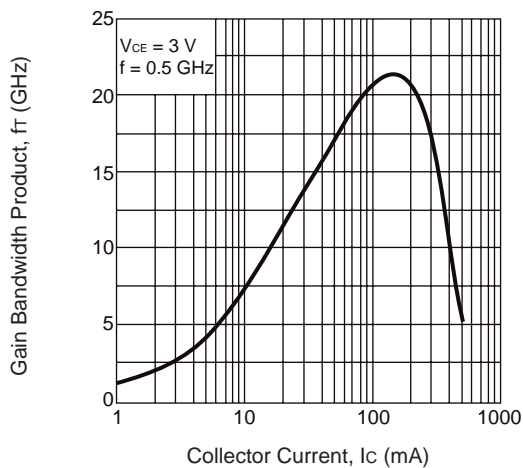
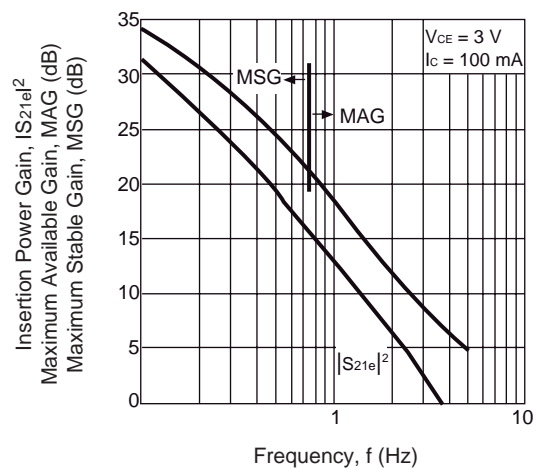
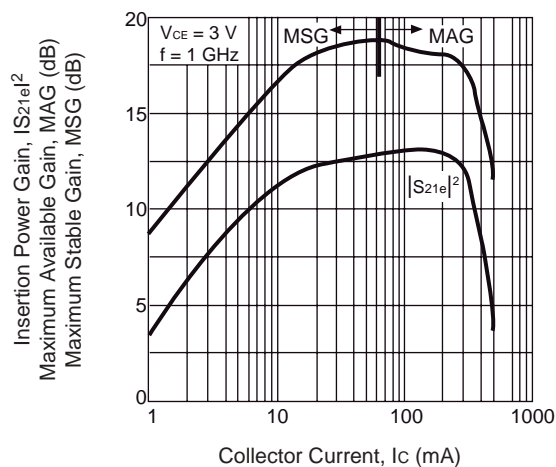
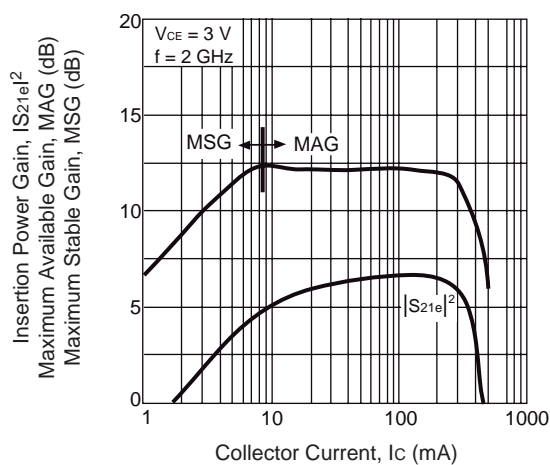
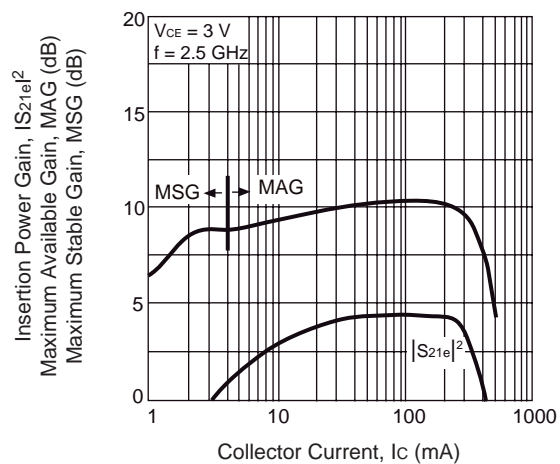


COLLECTOR CURRENT vs. COLLECTOR TO EMITTER VOLTAGE



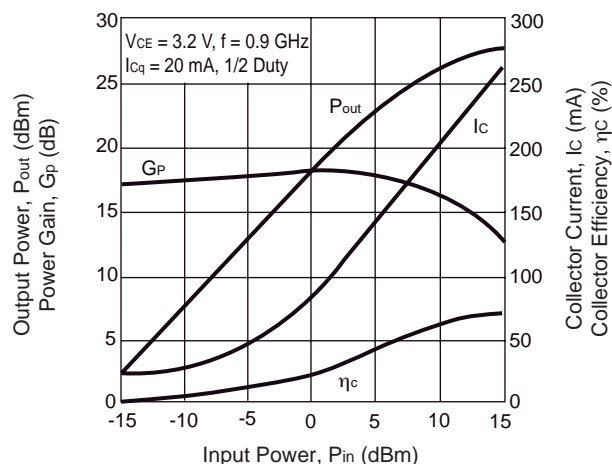
DC CURRENT GAIN vs. COLLECTOR CURRENT



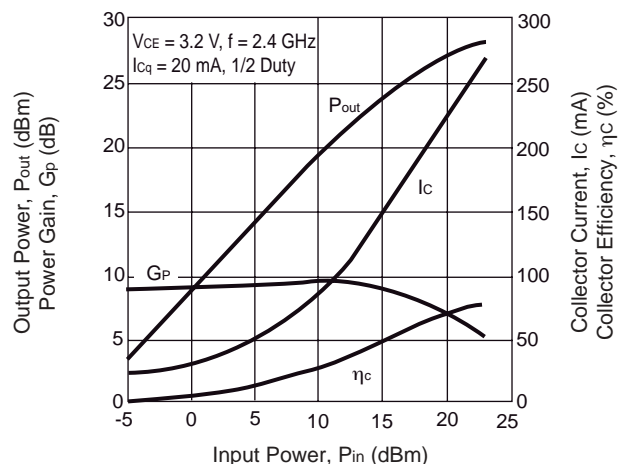
TYPICAL PERFORMANCE CURVES ( $T_A = 25^\circ\text{C}$ )GAIN BANDWIDTH PRODUCT vs.  
COLLECTOR CURRENTINSERTION POWER GAIN, MAG, MSG  
vs. FREQUENCYINSERTION POWER GAIN, MAG, MSG  
vs. COLLECTOR CURRENTINSERTION POWER GAIN, MAG, MSG  
vs. COLLECTOR CURRENTINSERTION POWER GAIN, MAG, MSG  
vs. COLLECTOR CURRENT

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

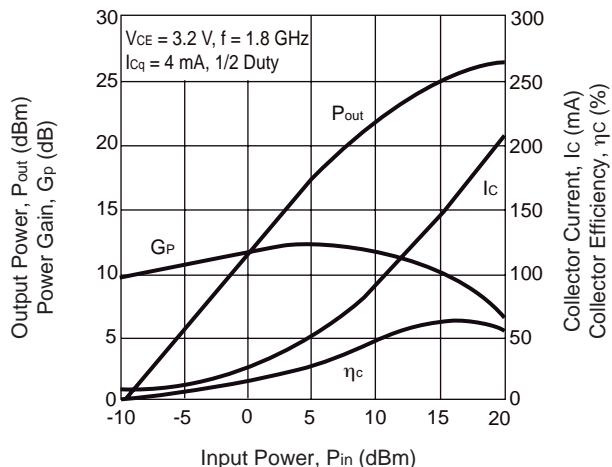
OUTPUT POWER, POWER GAIN, COLLECTOR CURRENT,  
& COLLECTOR EFFICIENCY  
vs. INPUT POWER



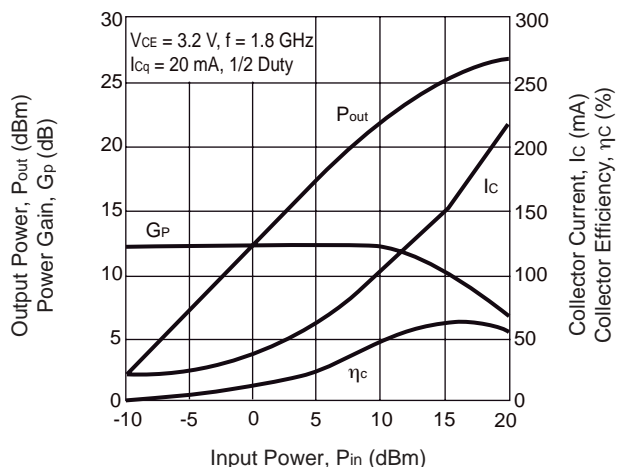
OUTPUT POWER, POWER GAIN, COLLECTOR CURRENT,  
& COLLECTOR EFFICIENCY  
vs. INPUT POWER



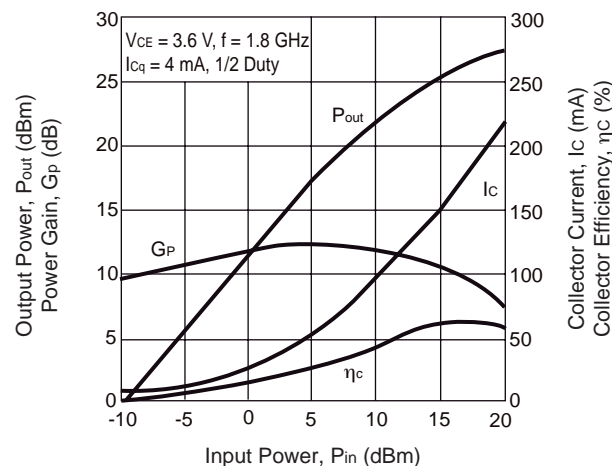
OUTPUT POWER, POWER GAIN, COLLECTOR CURRENT,  
& COLLECTOR EFFICIENCY  
vs. INPUT POWER



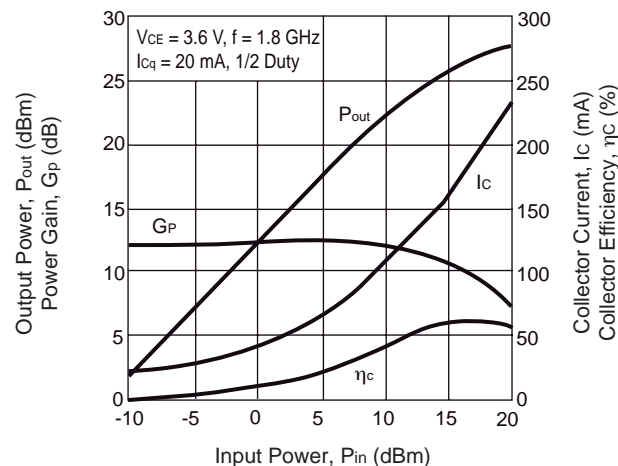
OUTPUT POWER, POWER GAIN, COLLECTOR CURRENT,  
& COLLECTOR EFFICIENCY  
vs. INPUT POWER



OUTPUT POWER, POWER GAIN, COLLECTOR CURRENT,  
& COLLECTOR EFFICIENCY  
vs. INPUT POWER

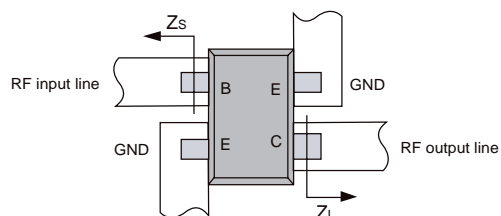
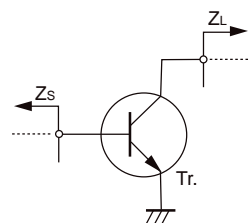


OUTPUT POWER, POWER GAIN, COLLECTOR CURRENT,  
& COLLECTOR EFFICIENCY  
vs. INPUT POWER

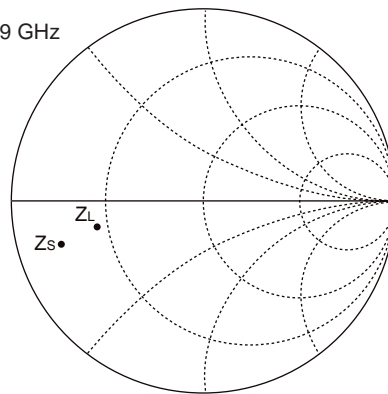


## LARGE SIGNAL IMPEDANCES

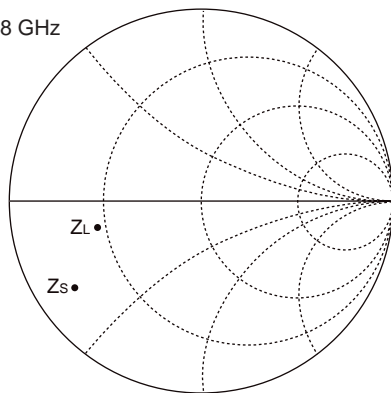
FREQUENCY $f$ (GHz)	COLLECTOR TO EMITTER VOLTAGE $V_{CE}$ (V)	SOURCE IMPEDANCE $Z_s$ ( $\Omega$ )	LOAD IMPEDANCE $Z_L$ ( $\Omega$ )
0.9	2.8 to 3.6	$8.4 - 5.2j$	$15.1 - 4.3j$
1.8	2.8 to 3.6	$6.3 - 16.4j$	$15.8 - 6.9j$
2.4	2.8 to 3.6	$5.9 - 22.1j$	$15.2 - 17.9j$



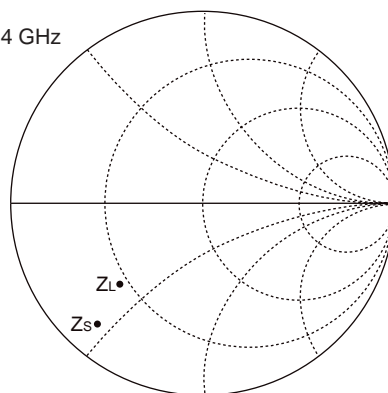
f = 0.9 GHz



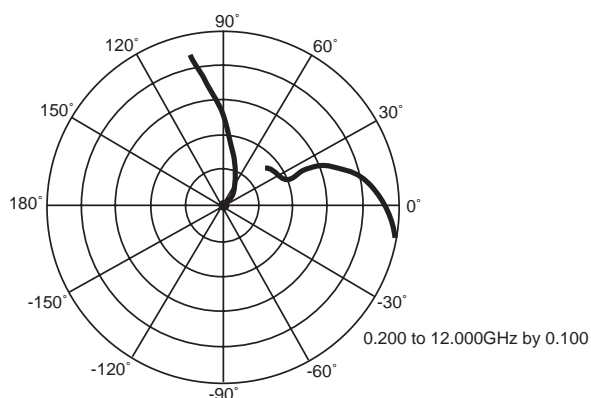
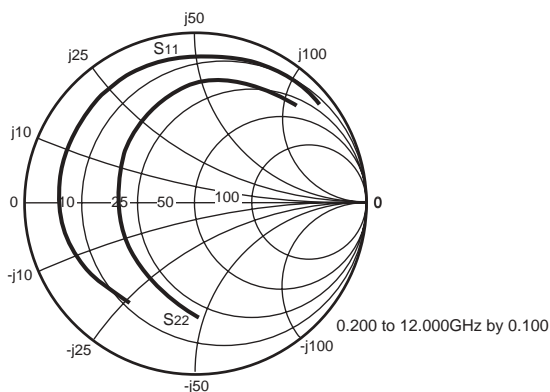
f = 1.8 GHz



f = 2.4 GHz



# TYPICAL SCATTERING PARAMETERS (T<sub>A</sub> = 25°C)



## NE664M04

V<sub>c</sub> = 1 V, I<sub>c</sub> = 10 mA

FREQUENCY	S <sub>11</sub>		S <sub>21</sub>		S <sub>12</sub>		S <sub>22</sub>		K	MAG <sup>1</sup>
GHz	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG		(dB)
0.50	0.784	-161.6	6.573	95.1	0.075	19.0	0.491	-138.6	0.32	19.44
1.00	0.801	178.1	3.389	77.6	0.081	16.3	0.454	-164.9	0.60	16.23
1.50	0.810	166.2	2.271	65.1	0.084	18.9	0.460	-178.3	0.85	14.33
2.00	0.812	157.2	1.710	54.4	0.090	18.1	0.467	172.5	1.03	11.77
2.50	0.820	149.0	1.378	44.3	0.097	20.8	0.476	165.3	1.16	9.14
3.00	0.827	141.5	1.163	35.2	0.109	20.6	0.482	158.0	1.20	7.60
3.50	0.834	133.6	1.013	26.1	0.119	18.7	0.498	151.0	1.22	6.47
4.00	0.838	125.9	0.901	17.1	0.133	16.2	0.508	143.9	1.22	5.49
4.50	0.845	118.0	0.816	8.6	0.146	11.6	0.525	136.4	1.19	4.84
5.00	0.850	110.4	0.743	0.1	0.160	8.6	0.546	128.9	1.17	4.15
5.50	0.855	102.3	0.678	- 7.5	0.170	5.7	0.570	121.9	1.19	3.40
6.00	0.861	95.2	0.624	- 14.9	0.175	0.9	0.599	115.4	1.18	2.93
6.50	0.866	88.6	0.573	- 21.9	0.190	- 3.9	0.625	108.6	1.15	2.44
7.00	0.874	82.3	0.530	- 28.0	0.195	- 7.7	0.650	102.4	1.14	2.05
7.50	0.881	76.5	0.485	- 34.0	0.198	- 12.6	0.676	95.6	1.14	1.58
8.00	0.889	72.0	0.451	- 38.9	0.203	- 17.2	0.696	89.6	1.13	1.29
8.50	0.898	67.3	0.422	- 44.1	0.211	- 21.6	0.716	83.0	1.09	1.14
9.00	0.905	63.5	0.391	- 48.5	0.205	- 25.6	0.733	76.4	1.11	0.76
9.50	0.911	60.2	0.360	- 52.4	0.208	- 30.2	0.740	70.9	1.11	0.34
10.00	0.916	56.1	0.337	- 56.3	0.208	- 33.9	0.768	63.4	1.12	0.01
10.50	0.917	52.2	0.321	- 60.0	0.209	- 38.7	0.782	58.1	1.12	- 0.24
11.00	0.926	48.4	0.305	- 64.1	0.210	- 42.2	0.793	53.2	1.09	- 0.27
11.50	0.923	44.4	0.295	- 66.4	0.208	- 46.5	0.811	49.2	1.11	- 0.52
12.00	0.931	40.0	0.290	- 69.9	0.221	- 50.7	0.816	46.3	1.06	- 0.27

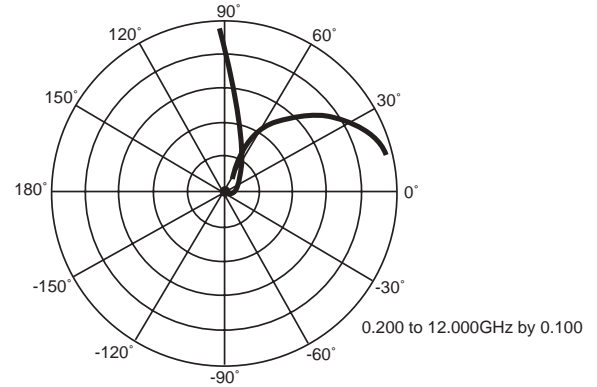
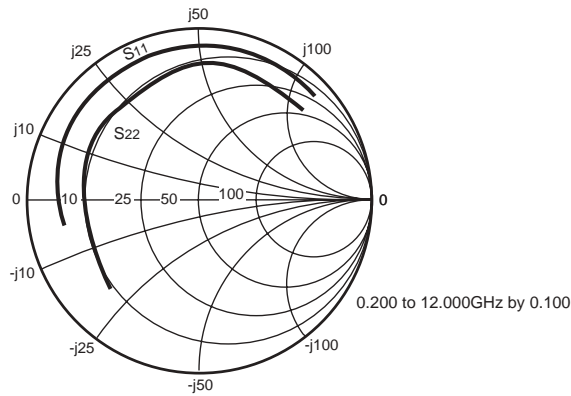
Note:

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<sub>A</sub> = 25°C)

## NE664M04

V<sub>C</sub> = 2 V, I<sub>C</sub> = 100 mA

FREQUENCY	S <sub>11</sub>		S <sub>21</sub>		S <sub>12</sub>		S <sub>22</sub>		K	MAG <sup>1</sup>
GHz	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG		(dB)
0.50	0.808	177.3	9.415	90.1	0.027	50.0	0.652	-167.8	0.87	25.50
1.00	0.812	167.0	4.762	77.9	0.046	62.1	0.650	176.3	1.04	18.88
1.50	0.819	158.7	3.176	68.6	0.065	57.6	0.657	166.5	1.07	15.33
2.00	0.822	151.3	2.387	60.0	0.083	53.6	0.662	158.5	1.08	12.85
2.50	0.830	143.8	1.925	51.6	0.106	48.0	0.666	151.4	1.06	11.12
3.00	0.831	137.2	1.616	43.8	0.123	43.3	0.670	144.1	1.07	9.60
3.50	0.834	129.9	1.410	36.0	0.140	37.1	0.669	137.0	1.07	8.45
4.00	0.837	122.8	1.256	27.7	0.159	30.9	0.672	129.3	1.06	7.52
4.50	0.836	115.1	1.138	19.7	0.175	25.2	0.680	121.7	1.06	6.61
5.00	0.843	107.7	1.035	12.1	0.188	18.1	0.691	114.7	1.06	5.96
5.50	0.843	100.1	0.945	4.4	0.197	11.6	0.701	108.2	1.06	5.25
6.00	0.851	93.1	0.868	- 2.5	0.207	6.4	0.715	101.9	1.06	4.71
6.50	0.857	86.5	0.800	- 9.0	0.212	- 0.2	0.731	95.8	1.06	4.23
7.00	0.865	80.8	0.742	- 15.3	0.222	- 4.7	0.745	90.2	1.06	3.80
7.50	0.866	75.4	0.688	- 21.2	0.225	- 10.8	0.751	84.5	1.07	3.29
8.00	0.874	70.6	0.641	- 26.6	0.225	- 15.7	0.761	78.7	1.07	2.94
8.50	0.883	66.5	0.591	- 32.4	0.227	- 19.8	0.772	72.4	1.07	2.56
9.00	0.891	62.6	0.551	- 37.1	0.231	- 25.9	0.774	66.3	1.06	2.24
9.50	0.900	59.2	0.517	- 43.0	0.221	- 30.6	0.788	60.8	1.06	2.17
10.00	0.902	55.6	0.491	- 47.2	0.226	- 34.5	0.796	54.7	1.07	1.80
10.50	0.914	51.8	0.456	- 52.1	0.219	- 39.4	0.805	49.5	1.06	1.69
11.00	0.918	48.1	0.435	- 56.2	0.219	- 43.8	0.810	45.5	1.05	1.54
11.50	0.917	44.1	0.419	- 60.1	0.219	- 47.4	0.822	41.9	1.06	1.31
12.00	0.917	39.7	0.413	- 63.7	0.229	- 50.6	0.822	38.8	1.05	1.13

Note:

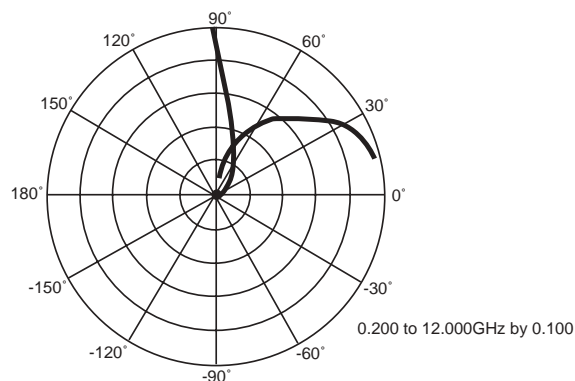
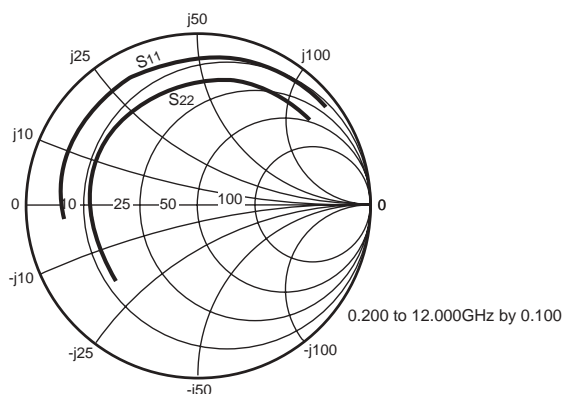
## 1. Gain Calculations:

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

MAG = Maximum Available Gain

MSG = Maximum Stable Gain



TYPICAL SCATTERING PARAMETERS (T<sub>A</sub> = 25°C)

## NE664M04

V<sub>c</sub> = 3 V, I<sub>c</sub> = 200 mA

FREQUENCY	S <sub>11</sub>		S <sub>21</sub>		S <sub>12</sub>		S <sub>22</sub>		K	MAG <sup>1</sup>
GHz	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG		(dB)
0.50	0.801	175.9	9.856	89.7	0.024	66.8	0.624	-169.4	1.01	25.43
1.00	0.808	166.3	4.975	77.5	0.044	68.0	0.632	175.5	1.07	18.85
1.50	0.815	158.4	3.310	68.2	0.066	62.1	0.633	166.7	1.07	15.41
2.00	0.819	150.9	2.483	59.8	0.084	57.6	0.638	158.1	1.08	12.95
2.50	0.822	143.9	1.996	51.6	0.102	52.3	0.644	150.8	1.09	11.11
3.00	0.830	136.8	1.676	43.6	0.122	43.9	0.648	144.1	1.07	9.80
3.50	0.832	129.7	1.461	35.8	0.138	39.2	0.653	136.7	1.07	8.62
4.00	0.831	122.5	1.299	27.6	0.156	32.6	0.656	129.3	1.07	7.59
4.50	0.835	115.0	1.171	19.8	0.173	26.9	0.662	122.1	1.07	6.75
5.00	0.837	107.6	1.069	12.0	0.187	19.5	0.672	114.9	1.06	6.05
5.50	0.842	100.2	0.979	4.4	0.198	11.8	0.683	108.2	1.06	5.44
6.00	0.848	93.0	0.896	- 2.8	0.211	7.0	0.698	102.1	1.06	4.83
6.50	0.853	86.4	0.828	- 9.1	0.214	1.2	0.711	96.2	1.06	4.32
7.00	0.862	80.5	0.764	- 15.4	0.216	- 4.7	0.724	90.6	1.06	3.92
7.50	0.868	75.4	0.707	- 21.5	0.226	- 9.8	0.736	85.1	1.06	3.47
8.00	0.873	70.4	0.660	- 26.8	0.231	- 15.6	0.748	78.9	1.06	3.08
8.50	0.881	66.5	0.611	- 32.7	0.223	- 20.4	0.750	72.7	1.07	2.72
9.00	0.890	62.7	0.572	- 36.9	0.226	- 24.0	0.764	67.2	1.07	2.45
9.50	0.895	59.3	0.532	- 42.0	0.226	- 30.2	0.771	61.0	1.07	2.11
10.00	0.903	55.7	0.498	- 47.9	0.219	- 33.8	0.779	55.0	1.07	1.91
10.50	0.911	52.0	0.466	- 51.7	0.224	- 38.3	0.793	48.9	1.06	1.64
11.00	0.915	48.3	0.445	- 56.3	0.219	- 43.0	0.794	45.8	1.06	1.53
11.50	0.919	44.1	0.430	- 60.1	0.226	- 46.2	0.810	41.6	1.05	1.40
12.00	0.918	39.8	0.426	- 64.6	0.229	- 49.5	0.811	39.3	1.05	1.34

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

## Life Support Applications

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