



# NEC's MEDIUM POWER NPN SILICON HIGH FREQUENCY TRANSISTOR

## NE678M04

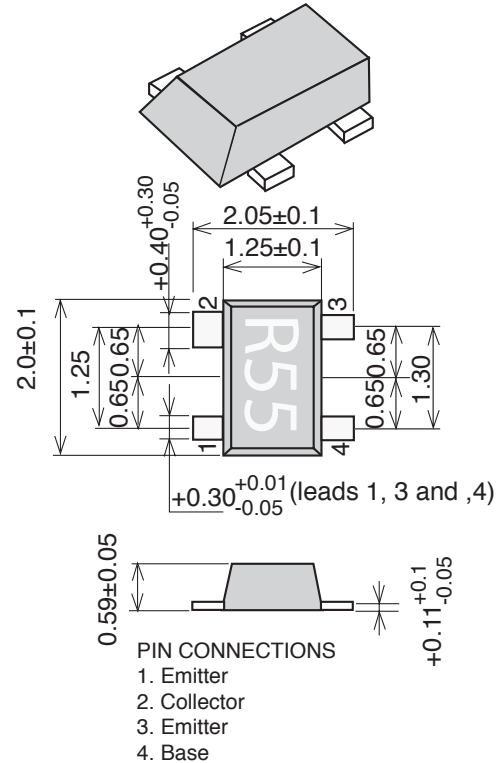
### FEATURES

- **HIGH GAIN BANDWIDTH:**  
f<sub>T</sub> = 12 GHz
- **HIGH OUTPUT POWER:**  
P<sub>-1dB</sub> = 18 dBm at 1.8 GHz
- **HIGH LINEAR GAIN:**  
G<sub>L</sub> = 13 dB at 1.8 GHz
- **NEW 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 NE678M04 is fabricated using NEC's HFT3 wafer process. With a transition frequency of 12 GHz, the NE678M04 is usable in applications from 100 MHz to 3 GHz. The NE678M04 provides P<sub>1dB</sub> of 18 dBm, even with low voltage and low current, making this device an excellent choice for the driver stage for mobile or fixed wireless applications.

The NE678M04 is housed in NEC's new low profile/flat lead style "M04" package



### ELECTRICAL CHARACTERISTICS (T<sub>A</sub> = 25°C)

PART NUMBER PACKAGE OUTLINE EIAJ <sup>3</sup> REGISTRATION NUMBER		NE678M04 M04 2SC5753				
SYMBOLS	PARAMETERS AND CONDITIONS	UNITS	MIN	TYP	MAX	
DC	I <sub>CBO</sub>	Collector Cutoff Current at V <sub>CB</sub> = 5V, I <sub>E</sub> = 0	nA		100	
	I <sub>EBO</sub>	Emitter Cutoff Current at V <sub>EB</sub> = 1 V, I <sub>C</sub> = 0	nA		100	
	h <sub>FE</sub>	DC Current <sup>1</sup> Gain at V <sub>CE</sub> = 3 V, I <sub>C</sub> = 30 mA		75	150	
RF	P <sub>1dB</sub>	Output Power at 1 dB compression point at V <sub>CE</sub> = 2.8 V, I <sub>CQ</sub> = 10 mA, f = 1.8 GHz, P <sub>in</sub> = 7 dBm	dBm		18.0	
	G <sub>L</sub>	Linear Gain at V <sub>CE</sub> = 2.8 V, I <sub>C</sub> = 10 mA, f = 1.8 GHz, P <sub>in</sub> = -5 dBm	dB		13.0	
	MAG	Maximum Available Gain <sup>4</sup> at V <sub>CE</sub> = 3 V, I <sub>C</sub> = 30 mA, f = 2 GHz	dBm		13.5	
	S <sub>21</sub>   <sup>2</sup>	Insertion Power Gain at V <sub>CE</sub> = 3 V, I <sub>C</sub> = 30 mA, f = 2 GHz	dB	8.0	10.5	
	η <sub>c</sub>	Collector Efficiency at V <sub>CE</sub> = 2.8 V, I <sub>CQ</sub> = 10 mA, f = 1.8 GHz, P <sub>in</sub> = 7 dBm	%		55	
	NF	Noise Figure at V <sub>CE</sub> = 3 V, I <sub>C</sub> = 7 mA, f = 2 GHz, Z <sub>S</sub> = Z <sub>opt</sub>	dB		1.7	2.5
	f <sub>T</sub>	Gain Bandwidth at V <sub>CE</sub> = 3 V, I <sub>C</sub> = 30 mA, f = 2 GHz	GHz		12.0	
	C <sub>re</sub>	Reverse Transfer Capacitance <sup>2</sup> at V <sub>CB</sub> = 3 V, I <sub>C</sub> = 0, f = 1 MHz	pF		0.42	0.7

Notes:

1. Pulsed measurement, pulse width ≤ 350 μs, duty cycle ≤ 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 Industrial Association of Japan.

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

**ABSOLUTE MAXIMUM RATINGS<sup>1</sup>** (T<sub>A</sub> = 25°C)

SYMBOLS	PARAMETERS	UNITS	RATINGS
V <sub>CB0</sub>	Collector to Base Voltage	V	9.0
V <sub>CE0</sub>	Collector to Emitter Voltage	V	6.0
V <sub>EB0</sub>	Emitter to Base Voltage	V	2.0
I <sub>C</sub>	Collector Current	mA	100
P <sub>T</sub>	Total Power Dissipation <sup>2</sup>	mW	205
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 a 1.08cm<sup>2</sup> x 1.0 mm thick glass epoxy PCB.

**ORDERING INFORMATION**

PART NUMBER	QUANTITY
NE678M04-T2-A	3k pcs./reel

**THERMAL RESISTANCE**

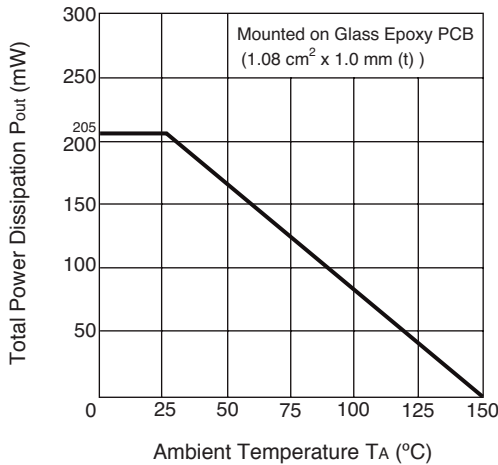
SYMBOLS	PARAMETERS	UNITS	RATINGS
R <sub>th j-a</sub>	Thermal Resistance from Junction to Ambient	°C/W	600

Note:

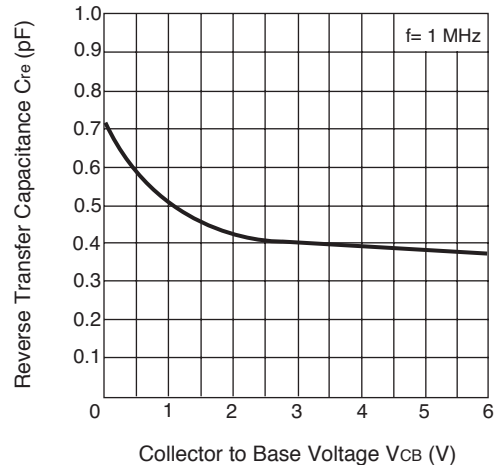
1. Mounted on a 1.08cm<sup>2</sup> x 1.0 mm thick glass epoxy PCB.

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

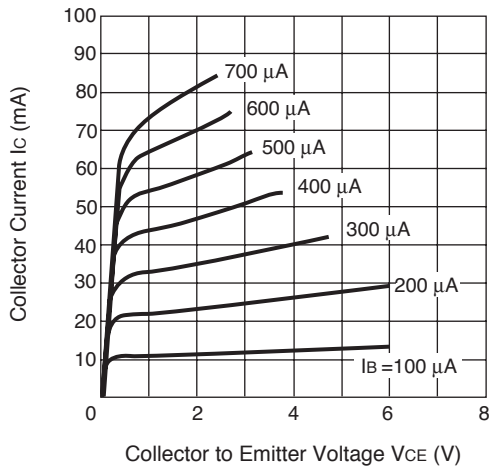
**TOTAL POWER DISSIPATION vs. AMBIENT TEMPERATURE**



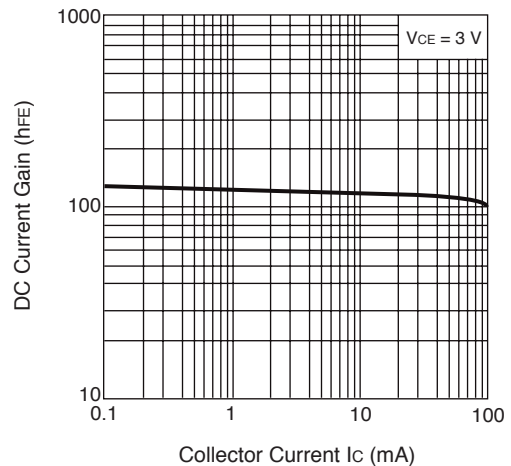
**REVERSE TRANSFER CAPACITANCE vs. COLLECTOR TO BASE VOLTAGE**



**COLLECTOR CURRENT vs. COLLECTOR TO EMITTER VOLTAGE**

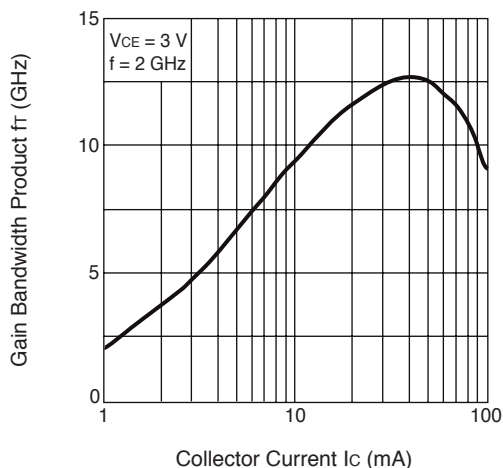


**DC CURRENT GAIN vs. COLLECTOR CURRENT**

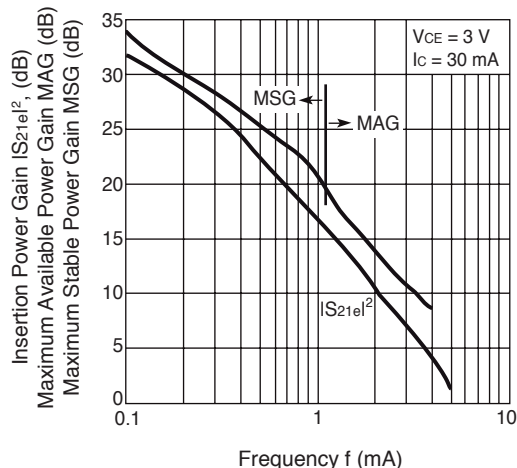


TYPICAL PERFORMANCE CURVES (TA = 25 °C)

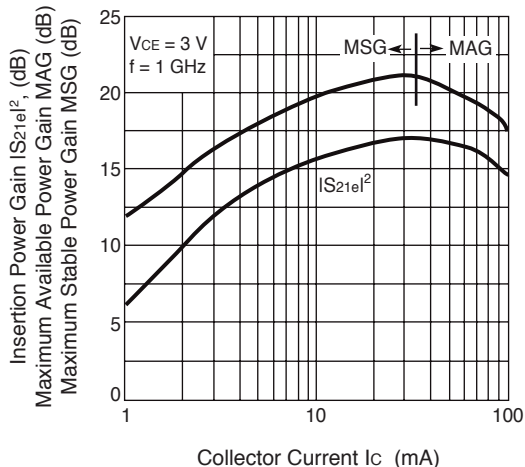
GAIN BANDWIDTH PRODUCT vs. COLLECTOR CURRENT



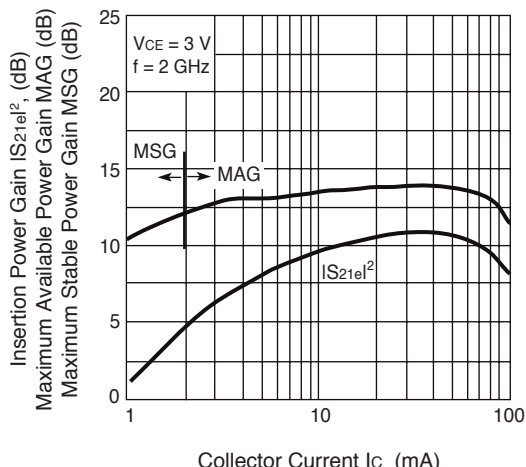
INSERTION POWER GAIN, MAG, MSG vs. FREQUENCY



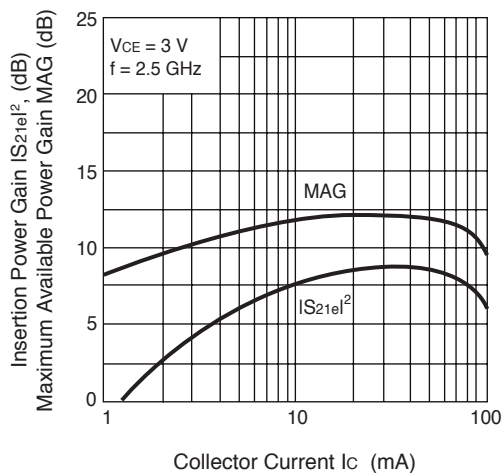
INSERTION POWER GAIN, MAG, MSG vs. COLLECTOR CURRENT



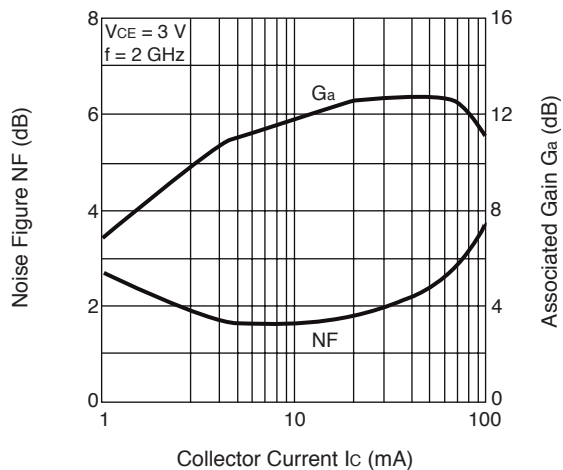
INSERTION POWER GAIN, MAG, MSG vs. COLLECTOR CURRENT



INSERTION POWER GAIN, MAG vs. COLLECTOR CURRENT

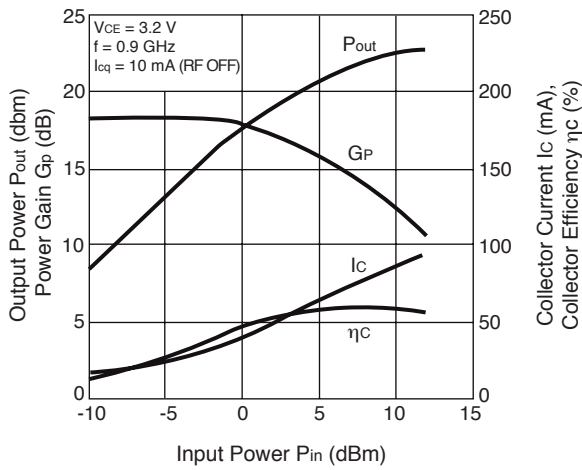


NOISE FIGURE, ASSOCIATED GAIN vs. COLLECTOR CURRENT

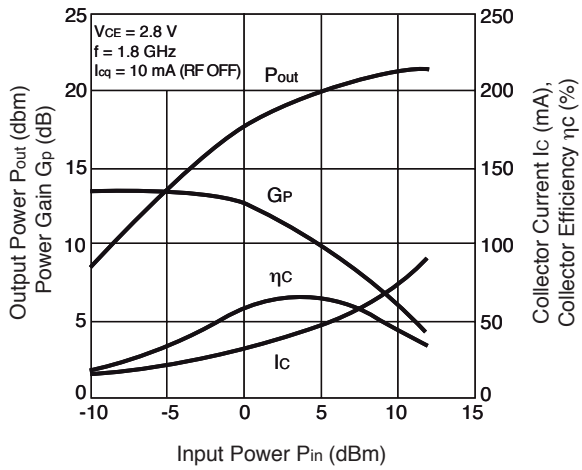


TYPICAL PERFORMANCE CURVES (T<sub>A</sub> = 25 °C)

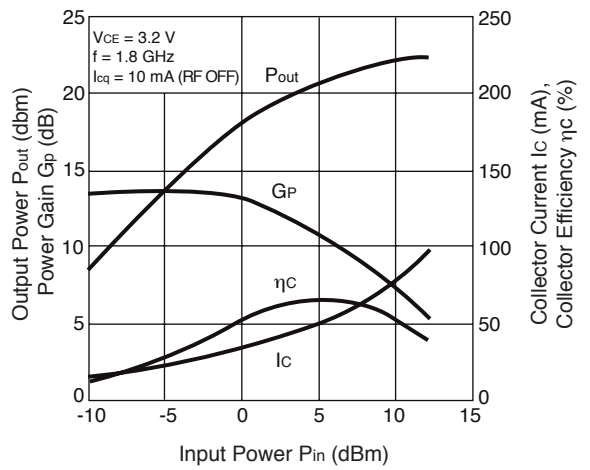
OUTPUT POWER, POWER GAIN, COLLECTOR CURRENT, COLLECTOR EFFICIENCY vs. INPUT POWER



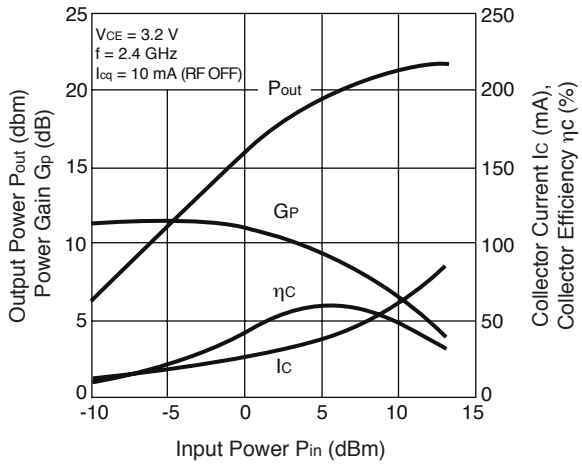
OUTPUT POWER, POWER GAIN, COLLECTOR CURRENT, COLLECTOR EFFICIENCY vs. INPUT POWER



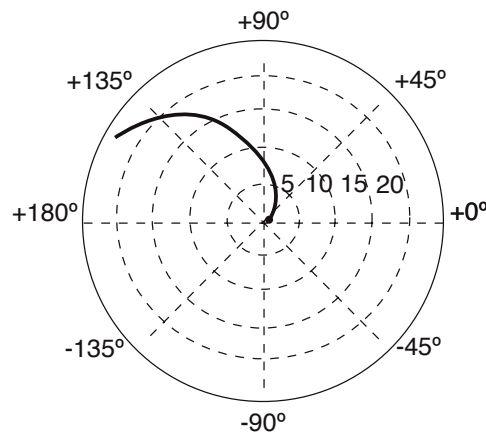
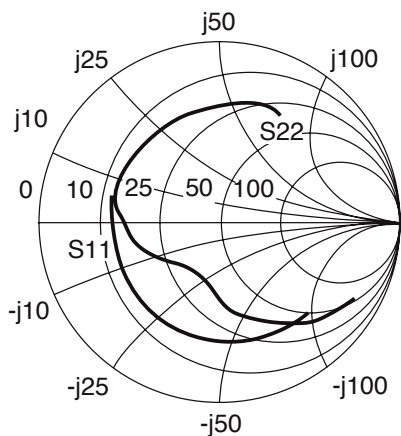
OUTPUT POWER, POWER GAIN, COLLECTOR CURRENT, COLLECTOR EFFICIENCY vs. INPUT POWER



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



**TYPICAL SCATTERING PARAMETERS** (TA = 25°C)



**NE678M04**

Vc = 2 V, Ic = 10 mA

FREQUENCY GHz	S11		S21		S12		S22		K	MAG <sup>1</sup> (dB)
	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG		
0.100	0.72	-45.97	23.42	152.40	0.02	65.62	0.90	-29.51	0.10	29.97
0.200	0.68	-81.43	19.17	132.28	0.04	52.02	0.74	-51.31	0.18	26.71
0.300	0.65	-106.66	15.41	118.19	0.05	42.17	0.61	-66.86	0.26	24.93
0.400	0.63	-124.06	12.56	108.21	0.05	37.11	0.52	-77.84	0.34	23.61
0.500	0.62	-136.69	10.53	100.63	0.06	33.66	0.46	-86.27	0.42	22.62
0.600	0.60	-148.20	8.85	94.98	0.06	32.53	0.38	-92.24	0.56	21.75
0.700	0.60	-155.78	7.72	89.80	0.06	31.81	0.36	-98.70	0.62	21.00
0.800	0.60	-161.77	6.86	85.45	0.06	31.70	0.34	-102.52	0.68	20.32
0.900	0.60	-167.38	6.15	81.38	0.07	31.29	0.33	-106.64	0.74	19.72
1.000	0.60	-171.69	5.59	77.66	0.07	31.31	0.32	-110.16	0.79	19.17
1.500	0.59	-170.30	3.81	61.44	0.08	33.17	0.31	-123.84	1.00	16.81
1.800	0.59	161.69	3.21	52.84	0.09	33.52	0.32	-130.08	1.07	13.98
1.900	0.59	158.90	3.05	50.05	0.09	33.69	0.32	-131.91	1.10	13.41
2.000	0.59	156.19	2.90	47.32	0.09	33.45	0.33	-133.96	1.11	12.93
2.500	0.59	142.62	2.35	33.99	0.11	32.55	0.36	-142.01	1.14	11.02
3.000	0.60	128.82	1.97	21.32	0.13	29.86	0.39	-149.47	1.15	9.63
3.500	0.61	114.69	1.69	9.12	0.14	26.40	0.43	-156.17	1.12	8.62
4.000	0.63	101.16	1.47	-2.44	0.16	21.89	0.47	-163.41	1.07	7.95
4.500	0.65	89.04	1.29	-13.44	0.18	16.66	0.50	-171.39	1.03	7.59
5.000	0.67	78.45	1.15	-23.86	0.19	10.92	0.53	179.62	0.98	7.69
5.500	0.69	68.99	1.02	-33.79	0.21	4.77	0.57	170.14	0.94	6.86
6.000	0.71	59.90	0.92	-43.00	0.23	-1.43	0.60	160.66	0.92	6.09

Note:

1. Gain Calculations:

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

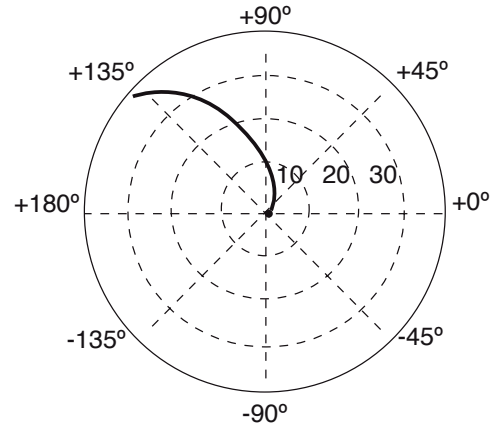
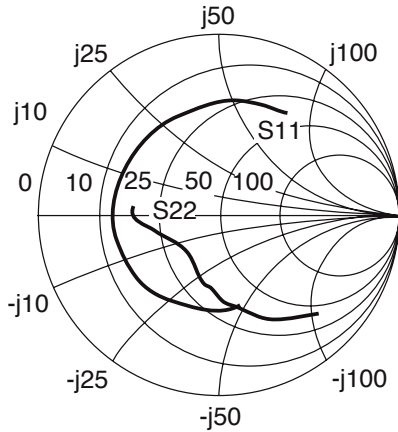
. When  $K \geq 1$ , MAG is undefined and MSG values are used.  $MSG = \frac{|S_{21}|}{|S_{12}|}$ ,  $K = \frac{1 + |\Delta|^2 - |S_{11}|^2 - |S_{22}|^2}{2 |S_{12}| |S_{21}|}$ ,  $\Delta = S_{11} S_{22} - S_{21} S_{12}$

MAG = Maximum Available Gain

MSG = Maximum Stable Gain

# NE678M04

## TYPICAL SCATTERING PARAMETERS (TA = 25°C)



### NE678M04

Vc = 3 V, Ic = 30 mA

FREQUENCY GHz	S11		S21		S12		S22		K	MAG <sup>1</sup> (dB)
	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG		
0.100	0.52	-74.30	39.85	141.89	0.02	63.14	0.79	-43.24	0.22	33.48
0.200	0.55	-114.70	28.29	120.64	0.03	50.10	0.58	-69.59	0.37	30.30
0.300	0.56	-136.33	20.98	108.33	0.03	45.90	0.46	-86.51	0.49	28.27
0.400	0.56	-149.34	16.42	100.26	0.03	45.26	0.40	-97.94	0.61	26.78
0.500	0.56	-158.35	13.45	94.25	0.04	45.86	0.36	-106.44	0.69	25.46
0.600	0.56	-167.02	11.22	90.08	0.04	47.13	0.30	-115.48	0.83	24.40
0.700	0.57	-172.39	9.70	85.86	0.04	48.18	0.28	-121.83	0.88	23.43
0.800	0.57	-176.68	8.57	82.27	0.05	49.01	0.27	-125.22	0.92	22.51
0.900	0.57	179.14	7.66	78.87	0.05	49.82	0.27	-128.89	0.96	21.72
1.000	0.57	176.07	6.93	75.71	0.06	50.22	0.26	-131.89	0.98	20.95
1.500	0.57	161.30	4.70	61.65	0.08	49.69	0.27	-142.80	1.07	16.35
1.800	0.57	153.82	3.96	53.96	0.09	48.26	0.27	-147.21	1.09	14.70
1.900	0.57	151.23	3.76	51.43	0.09	47.59	0.28	-148.33	1.09	14.25
2.000	0.57	148.83	3.58	48.96	0.10	46.86	0.28	-149.67	1.09	13.81
2.500	0.57	136.19	2.90	36.74	0.12	42.26	0.31	-154.80	1.09	12.03
3.000	0.57	123.25	2.44	24.91	0.14	36.84	0.34	-159.87	1.08	10.71
3.500	0.58	109.78	2.10	13.41	0.16	30.78	0.37	-164.45	1.06	9.71
4.000	0.60	96.93	1.84	2.30	0.18	24.27	0.40	-170.06	1.04	9.03
4.500	0.62	85.43	1.63	-8.43	0.19	17.67	0.43	-176.72	1.01	8.78
5.000	0.64	75.45	1.46	-18.79	0.21	11.05	0.47	-175.39	0.98	8.46
5.500	0.65	66.54	1.32	-28.80	0.22	4.47	0.50	166.91	0.95	7.72
6.000	0.67	57.90	1.19	-38.45	0.24	-2.21	0.53	158.44	0.93	7.05

Note:

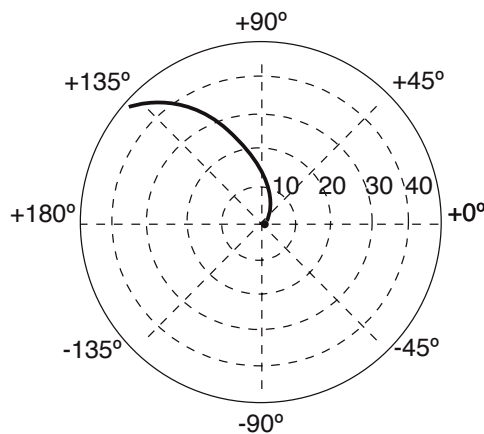
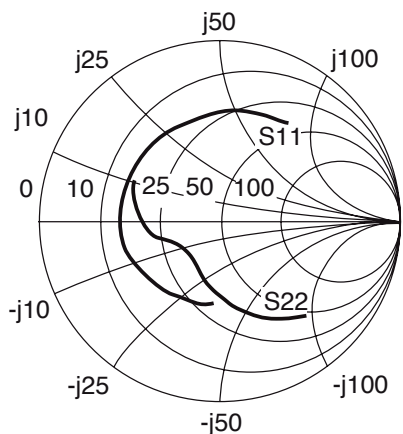
1. Gain Calculations:

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

MAG = Maximum Available Gain

MSG = Maximum Stable Gain

**TYPICAL SCATTERING PARAMETERS** (TA = 25°C)



**NE678M04**

Vc = 5 V, Ic = 70 mA

FREQUENCY GHz	S11		S21		S12		S22		K	MAG <sup>1</sup> (dB)
	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG		
0.100	0.46	-92.27	47.62	136.35	0.01	61.08	0.69	-50.06	0.35	35.14
0.200	0.51	-129.65	31.64	115.69	0.02	51.85	0.49	-77.41	0.51	31.73
0.300	0.53	-147.72	22.84	104.50	0.03	50.27	0.39	-94.24	0.65	29.60
0.400	0.54	-158.40	17.67	97.25	0.03	51.38	0.34	-105.50	0.76	27.89
0.500	0.55	-165.77	14.38	91.83	0.03	53.36	0.31	-113.55	0.84	26.43
0.600	0.55	-173.25	11.98	88.17	0.04	54.92	0.26	-123.64	0.94	25.20
0.700	0.56	-177.75	10.33	84.28	0.04	55.88	0.25	-129.49	0.98	24.08
0.800	0.56	178.53	9.12	80.93	0.04	56.52	0.25	-132.28	1.00	22.69
0.900	0.56	174.86	8.14	77.76	0.05	56.38	0.24	-135.41	1.02	21.26
1.000	0.56	172.16	7.36	74.77	0.05	57.10	0.24	-138.20	1.04	20.18
1.500	0.56	158.57	4.98	61.30	0.08	55.00	0.25	-147.24	1.08	16.43
1.800	0.55	151.40	4.19	53.86	0.09	52.53	0.26	-150.84	1.09	14.89
1.900	0.55	148.96	3.98	51.41	0.09	51.60	0.26	-151.75	1.09	14.44
2.000	0.55	146.64	3.79	49.00	0.10	50.56	0.27	-152.82	1.09	14.02
2.500	0.55	134.28	3.07	37.07	0.12	44.90	0.29	-157.03	1.09	12.29
3.000	0.56	121.53	2.58	25.46	0.14	38.56	0.32	-161.31	1.07	10.96
3.500	0.57	108.26	2.22	14.13	0.16	32.10	0.36	-165.52	1.06	9.97
4.000	0.58	95.62	1.95	3.18	0.18	25.40	0.39	-170.85	1.03	9.29
4.500	0.60	84.34	1.73	-7.49	0.20	18.42	0.42	-177.21	1.01	9.02
5.000	0.62	74.53	1.55	-17.79	0.21	11.57	0.45	175.01	0.98	8.67
5.500	0.64	65.76	1.40	-27.80	0.22	4.84	0.48	166.70	0.96	7.95
6.000	0.65	57.22	1.27	-37.47	0.24	-1.99	0.51	158.43	0.94	7.29

Note:

1. Gain Calculations:

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

. When  $K \geq 1$ , 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

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.

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

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02/07/2002

Subject: Compliance with EU Directives

CEL certifies, to its knowledge, that semiconductor and laser products detailed below are compliant with the requirements of European Union (EU) Directive 2002/95/EC Restriction on Use of Hazardous Substances in electrical and electronic equipment (RoHS) and the requirements of EU Directive 2003/11/EC Restriction on Penta and Octa BDE.

CEL Pb-free products have the same base part number with a suffix added. The suffix –A indicates that the device is Pb-free. The –AZ suffix is used to designate devices containing Pb which are exempted from the requirement of RoHS directive (\*). In all cases the devices have Pb-free terminals. All devices with these suffixes meet the requirements of the RoHS directive.

This status is based on CEL’s understanding of the EU Directives and knowledge of the materials that go into its products as of the date of disclosure of this information.

Restricted Substance per RoHS	Concentration Limit per RoHS (values are not yet fixed)	Concentration contained in CEL devices	
		-A	-AZ
Lead (Pb)	< 1000 PPM	Not Detected	(*)
Mercury	< 1000 PPM	Not Detected	
Cadmium	< 100 PPM	Not Detected	
Hexavalent Chromium	< 1000 PPM	Not Detected	
PBB	< 1000 PPM	Not Detected	
PBDE	< 1000 PPM	Not Detected	

If you should have any additional questions regarding our devices and compliance to environmental standards, please do not hesitate to contact your local representative.

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