

FEATURES

- **LOW NOISE FIGURE:** 1 dB at 70 MHz
- **HIGH RELIABILITY METALLIZATION**
- **LINEAR POWER OUTPUT:** 200 mW at 2 GHz
- **LOW COST**

DESCRIPTION

The NE416 series of NPN transistors is one of NEC's most versatile and widely used microwave transistors. The series provides economical solutions to a wide range of amplifier and oscillator problems. Low noise figures, high gain and high current capability achieve wide dynamic range and excellent linearity. The NE416 series is available in a wide selection of package styles and in chip form for thin and thick film circuits. Most package styles are available with screening levels through space grade. The series is volume pro-

duced, using the latest techniques and production controls patterned after MIL-S-19500. Of special importance is the use of NEC's high reliability metallization system (Pt-Si-Ti/Pt/Au) which offers the utmost in performance, reliability, and permits high temperature operation (100°C) at rated dissipation. The NE416 series offers superior performance and reliability at prices usually lower than less reliable moly-gold or aluminum transistors.



ELECTRICAL CHARACTERISTICS (TA = 25°C)

PART NUMBER EIAJ ¹ REGISTERED NUMBER PACKAGE OUTLINE			NE41612 2SC2025 (GrdD) 12 (TO-72)			NE41615 2SC1426 (GrdCX) 15 (TO-33)			NE41635 35 (MICRO-X)		
SYMBOLS	PARAMETERS AND CONDITIONS	UNITS	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX
f _T	Gain Bandwidth Product at V _{CE} = 5 V, I _C = 25 mA V _{CE} = 10 V, I _C = 50 mA	GHz GHz	1.5	2.7		2	3.5		2	3.5	
NF _{MIN}	Minimum Noise Figure at V _{CE} = 10 V, I _C = 5 mA, R _G = 50 Ω f = 0.2 GHz f = 0.5 GHz f = 1.0 GHz	dB dB dB		2.3 2.8 5	4		1.4 1.5 3.7			1.5 3.5	
S _{21E} ²	Insertion Power Gain at V _{CE} = 10 V, I _C = 30 mA, f = 0.5 GHz f = 1.0 GHz	dB dB		13 8			13 8		7	16 9.5	
h _{FE}	Forward Current Gain ² Ratio at V _{CB} = 5 V, I _C = 25 mA V _{CB} = 10 V, I _C = 50 mA		30	100	200	30	100	200	30	100	200
I _{CBO}	Collector Cutoff Current at V _{CB} = 20 V, I _E = 0	μA			0.1			0.1			0.1
I _{EBO}	Emitter Cutoff Current at V _{EB} = 2 V, I _C = 0	μA			0.1			0.1			0.1
C _{CB}	Collector to Base Capacitance ³ at V _{CB} = 5 V, I _E = 0 mA, f = 1.0 MHz V _{CB} = 10 V, I _E = 0, f = 1.0 MHz	pF		1.3	2		1	2		1	2
P _T	Total Power Dissipation (TA = 25°C)	W			.50			3.5			.29
R _{TH(J-C)}	Thermal Resistance (Junction to Case)	°C/W			50			50			50

Notes:

1. Electronic Industrial Association of Japan.
2. Pulse measurement Duty Cycle < 2%, PW < 30 ns.
3. CCB measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter terminal shall be connected to the guard terminal.

NE416 SERIES

ABSOLUTE MAXIMUM RATINGS¹ (T_A = 25°C)

SYMBOLS	PARAMETERS	UNITS	RATINGS
V _{CB0}	Collector to Base Voltage	V	35
V _{CE0}	Collector to Emitter Voltage	V	18
V _{EB0}	Emitter to Base Voltage	V	3
I _c	Collector Current	mA	100
T _J	Junction Temperature	°C	200 ²
T _{STG}	Storage Temperature	°C	-65 to +200 ²

Notes:

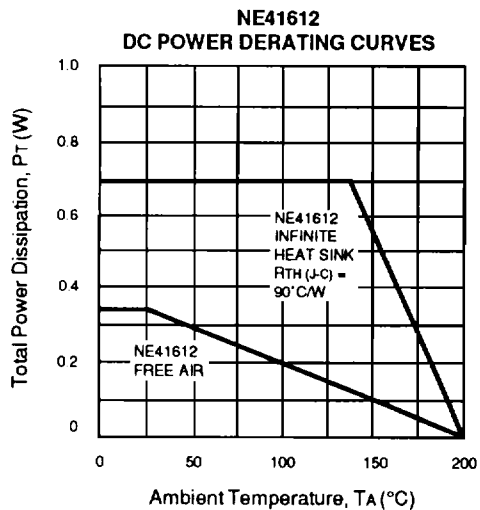
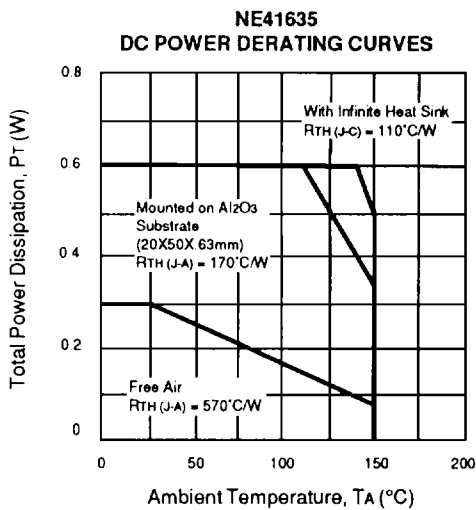
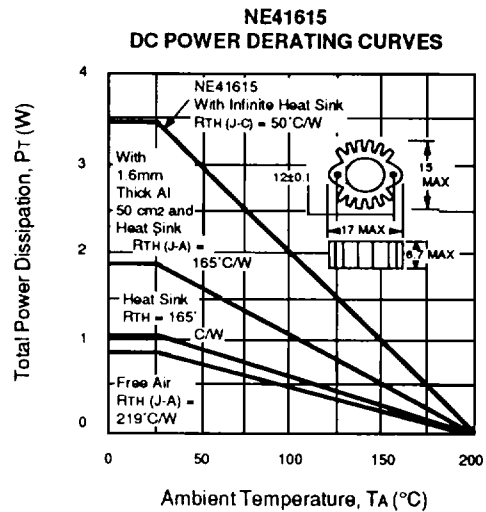
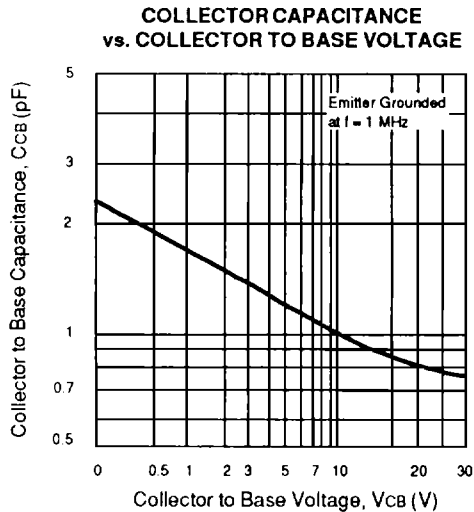
- Operation in excess of any one of these parameters may result in permanent damage.
- Maximum Storage Temperature (T_{STG}) for the NE41635 is -65°C to 150°C. The leads of the NE41635 are Sn plated and may tarnish above 150°C. Once soldered into a circuit, the unit can be stored at 200.

NE41635

TYPICAL NOISE PARAMETERS (T_A = 25°C)

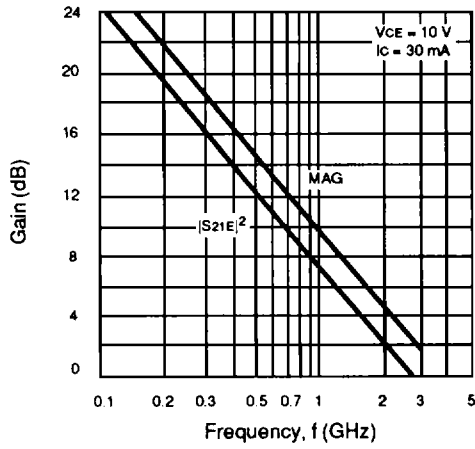
FREQ. (MHz)	NF _{MN} (dB)	G _A (dB)	Γ _{OPT}		R _n /50
			MAG	ANG	
V _{DS} = 10 V, I _c = 5 mA					
500	1.8	15.3	.40	128	.17
1000	3.0	11.1	.58	171	.10
1500	4.2	8.3	.69	-174	.14
2000	4.8	6.7	.68	-162	.26
V _{DS} = 10 V, I _c = 20 mA					
500	2.4	17.5	.42	159	.13
1000	3.6	12.7	.59	180	.10
1500	4.9	9.8	.67	-169	.15
2000	5.6	8.8	.73	-159	.50

TYPICAL PERFORMANCE CURVES (T_A = 25°C)

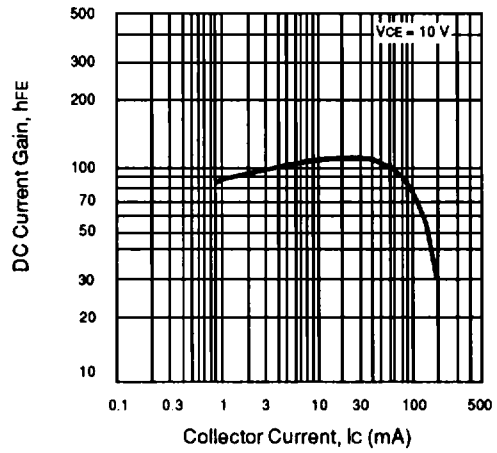


TYPICAL PERFORMANCE CURVES (TA = 25°C)

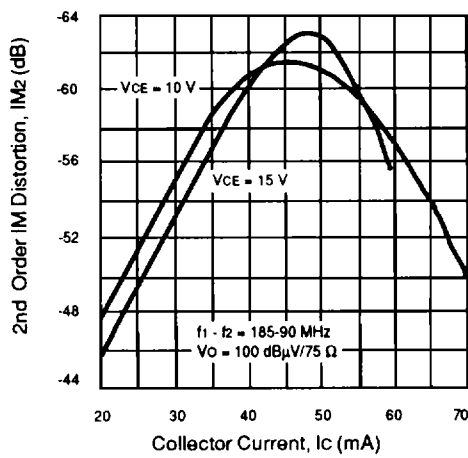
NE41612 AND NE41615
FORWARD INSERTION GAIN
AND MAXIMUM AVAILABLE GAIN
vs. FREQUENCY



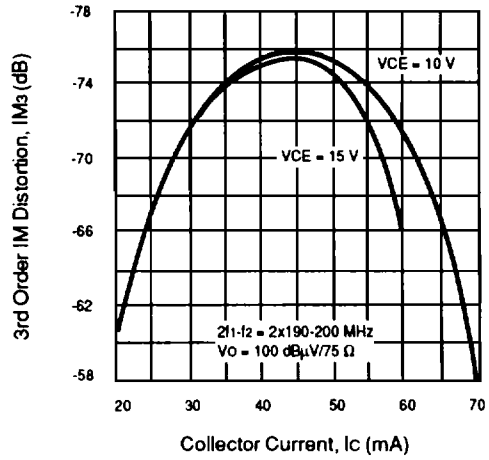
DC CURRENT GAIN
vs. COLLECTOR CURRENT



NE41615
SECOND ORDER IM DISTORTION
vs. COLLECTOR CURRENT



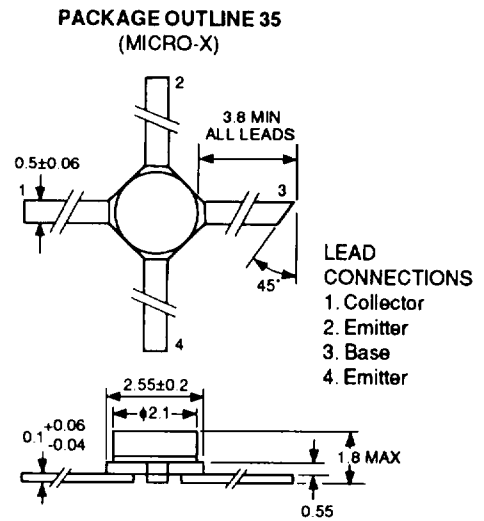
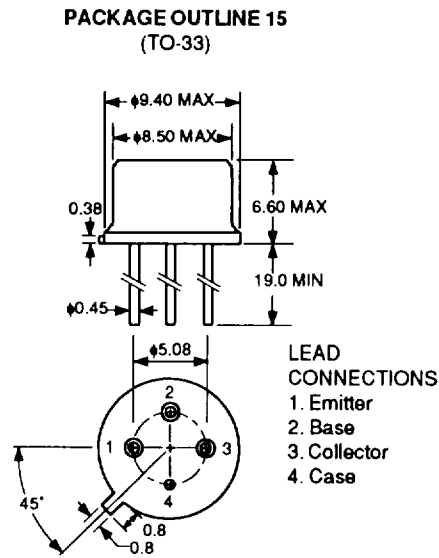
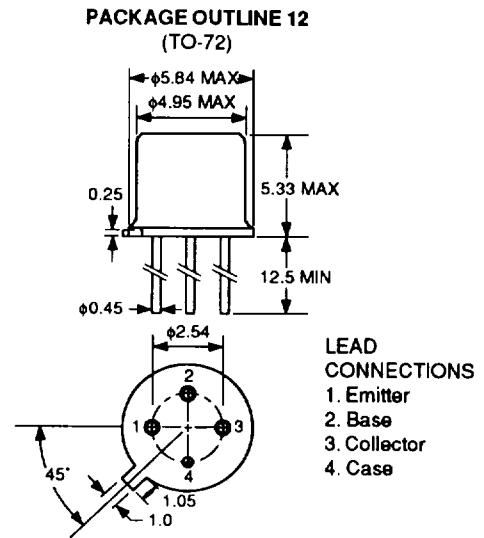
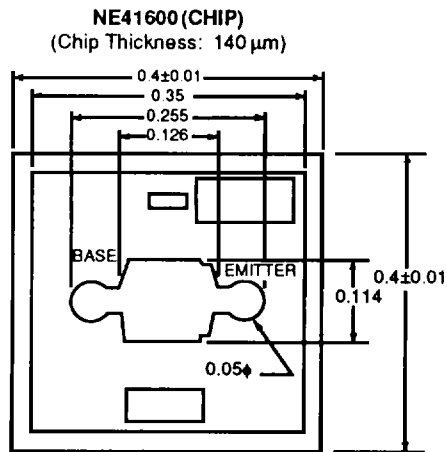
NE41615
THIRD ORDER IM DISTORTION
vs. COLLECTOR CURRENT



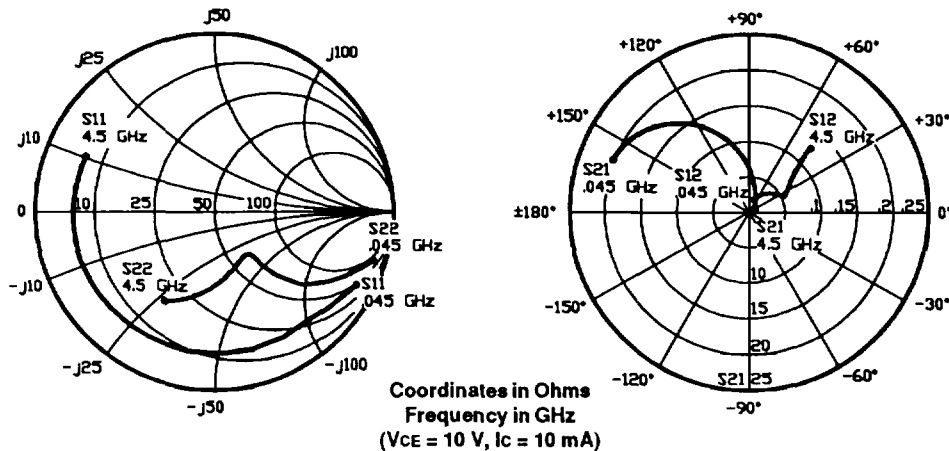
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NE416 SERIES

OUTLINE DIMENSIONS (Units in mm)



TYPICAL COMMON EMITTER SCATTERING PARAMETERS (TA = 25°C)



NE41600

VCE = 10 V, IC = 10 mA

FREQUENCY (MHz)	S ₁₁		S ₂₁		S ₁₂		S ₂₂		K	MAG ¹ (dB)
	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG		
0.045	.809	-36.00	20.378	159.00	.018	71.00	.930	-17.00	0.08	30.5
0.050	.808	-39.20	20.094	157.40	.019	69.55	.916	-18.15	0.08	30.2
0.100	.800	-71.20	17.255	141.40	.031	55.05	.774	-29.65	0.12	27.5
0.200	.790	-117.05	12.256	117.65	.045	35.95	.552	-43.85	0.21	24.4
0.300	.790	-139.25	8.815	105.05	.050	28.80	.430	-48.10	0.30	22.5
0.400	.789	-150.40	6.745	97.15	.052	25.90	.368	-49.00	0.41	21.1
0.500	.789	-157.30	5.445	91.25	.054	25.00	.334	-49.55	0.51	20.0
0.600	.789	-162.20	4.567	87.35	.055	25.55	.316	-50.55	0.60	19.2
0.700	.788	-165.65	3.915	83.80	.056	26.55	.307	-51.55	0.69	18.4
0.800	.786	-168.65	3.418	80.35	.058	27.00	.302	-53.10	0.77	17.7
0.900	.787	-171.10	3.050	77.35	.059	28.10	.300	-55.10	0.84	17.1
1.000	.787	-173.10	2.764	74.35	.060	29.55	.299	-57.10	0.92	16.6
1.500	.785	-179.00	1.852	61.35	.068	34.55	.323	-67.10	1.18	11.8
2.000	.784	175.45	1.382	49.90	.076	39.00	.361	-78.10	1.37	9.0
2.500	.780	171.00	1.111	39.90	.087	42.00	.405	-87.10	1.43	7.2
3.000	.778	167.00	0.919	30.35	.096	44.00	.449	-96.10	1.48	5.7
3.500	.779	163.45	0.778	21.90	.106	45.55	.495	-104.55	1.46	4.6
4.000	.779	160.00	0.667	14.90	.116	47.00	.537	-112.10	1.44	3.7
4.500	.779	156.45	0.574	8.45	.126	47.00	.575	-119.10	1.43	2.7

VCE = 10 V, IC = 20 mA

0.045	0.738	-53.00	31.208	153.00	0.017	64.00	0.872	-25.00	0.10	32.6
0.050	0.739	-56.50	30.566	151.20	0.018	62.60	0.854	-26.20	0.11	32.3
0.100	0.754	-91.50	24.149	133.20	0.025	48.60	0.671	-38.20	0.16	29.8
0.200	0.774	-135.65	14.738	109.30	0.034	32.70	0.422	-51.75	0.30	26.4
0.300	0.782	-152.05	9.980	99.15	0.037	29.45	0.315	-54.00	0.44	24.3
0.400	0.783	-160.30	7.485	93.25	0.038	30.10	0.267	-54.55	0.58	22.9
0.500	0.784	-165.20	5.979	88.80	0.040	31.55	0.243	-55.00	0.70	21.7
0.600	0.785	-168.65	4.993	84.80	0.042	33.65	0.230	-55.00	0.80	20.8
0.700	0.783	-171.65	4.276	81.35	0.045	36.10	0.224	-55.55	0.88	19.8
0.800	0.784	-174.10	3.725	78.35	0.047	37.55	0.221	-57.10	0.97	19.0
0.900	0.786	-175.55	3.317	75.35	0.049	39.10	0.222	-58.55	1.03	17.2
1.000	0.784	-177.10	3.003	72.90	0.051	40.55	0.224	-60.10	1.10	15.8
1.500	0.782	177.45	2.008	60.90	0.064	45.55	0.252	-69.10	1.28	11.8
2.000	0.779	172.45	1.507	50.35	0.077	48.00	0.292	-79.10	1.38	9.2
2.500	0.775	169.45	1.205	39.90	0.088	49.00	0.338	-88.10	1.46	7.3
3.000	0.776	165.45	1.002	30.90	0.100	49.00	0.386	-96.10	1.44	6.1
3.500	0.774	162.45	0.840	22.90	0.111	49.00	0.433	-104.10	1.47	4.7
4.000	0.775	159.00	0.722	15.45	0.122	49.00	0.478	-111.55	1.44	3.8
4.500	0.775	155.45	0.626	8.90	0.132	49.00	0.520	-118.10	1.43	2.9

Note:

1. Gain Calculations:

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

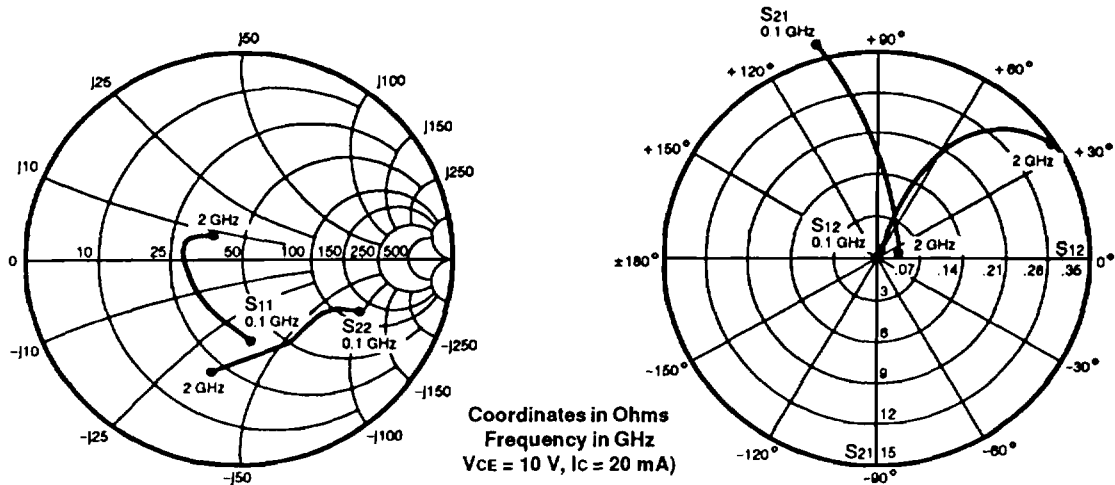
When $K \leq 1$, MAG is undefined and MSG values are used. $MSG = \frac{|S_{21}|}{|S_{12}|}$, $K = \frac{1 + |\Delta|^2 - |S_{11}|^2 - |S_{22}|^2}{2 |S_{12} S_{21}|}$, $\Delta = S_{11} S_{22} - S_{21} S_{12}$

MAG = Maximum Available Gain, MSG = Maximum Stable Gain



NE416 SERIES

TYPICAL COMMON EMITTER SCATTERING PARAMETERS (TA = 25°C)



NE41612

VCE = 5 V, IC = 2 mA

FREQUENCY (MHz)	S11		S21		S12		S22		K	MAG ¹ (dB)
	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG		
100	.83	-52	6.06	141	.05	58	.89	-20	0.245	20.835
200	.69	-87	4.45	118	.09	49	.76	-31	0.341	16.941
500	.52	-143	2.25	81	.12	39	.59	-46	0.823	12.730
1000	.49	172	1.31	49	.16	54	.55	-69	1.100	7.208
1500	.44	139	.97	28	.25	59	.59	-92	1.006	5.402
2000	.35	108	.82	12	.36	48	.60	-115	1.017	2.781

VCE = 10 V, IC = 5 mA

100	.68	-60	10.41	132	.03	62	.80	-22	0.409	25.403
200	.51	-95	6.94	110	.06	54	.65	-30	0.613	20.632
500	.37	-148	3.24	79	.10	57	.53	-40	0.961	15.105
1000	.34	170	1.79	52	.17	61	.51	-59	1.054	8.802
1500	.30	145	1.32	30	.25	58	.55	-82	0.977	7.226
2000	.22	122	1.05	9	.32	46	.58	-104	0.969	5.160

VCE = 10 V, IC = 20 mA

100	.52	-73	13.86	122	.02	62	.69	-25	0.753	28.407
200	.38	-105	8.38	102	.05	59	.56	-31	0.814	22.243
500	.29	-155	3.71	77	.11	63	.46	-39	0.969	15.280
1000	.27	169	2.02	51	.19	61	.45	-57	1.034	9.143
1500	.24	149	1.48	30	.26	53	.50	-80	0.994	7.553
2000	.17	135	1.18	9	.32	41	.56	-100	0.979	5.667

VCE = 10 V, IC = 20 mA

100	.39	-83	16.25	114	.02	62	.60	-27	0.933	29.098
200	.29	-114	9.23	98	.04	65	.49	-30	1.042	22.382
500	.25	-159	3.97	75	.11	67	.42	-38	1.004	15.168
1000	.24	168	2.15	51	.20	60	.41	-56	1.028	9.285
1500	.20	152	1.57	30	.28	51	.46	-78	0.989	7.487
2000	.14	145	1.24	9	.33	37	.53	-98	0.992	5.749

VCE = 10 V, IC = 30 mA

100	.34	-89	16.82	111	.02	65	.56	-27	0.517	34.470
200	.26	-119	9.37	96	.04	66	.47	-28	1.518	20.546
500	.24	-162	4.00	74	.11	68	.41	-37	1.198	15.094
1000	.23	167	2.16	51	.20	61	.41	-56	1.140	12.306
1500	.20	152	1.57	30	.28	51	.45	-78	1.139	10.439
2000	.14	145	1.24	8	.33	36	.52	-98	1.328	6.896

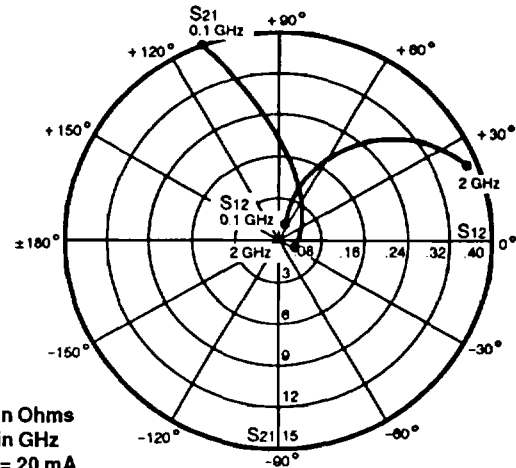
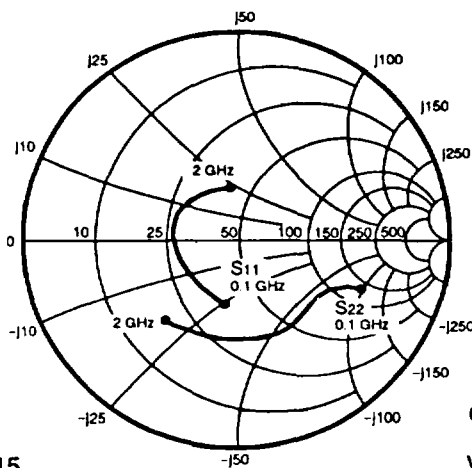
Note:

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. $MSG = \frac{|S_{21}|}{|S_{12}|}$, $K = \frac{1 + |\Delta|^2 - |S_{11}|^2 - |S_{22}|^2}{2 |S_{12} S_{21}|}$, $\Delta = S_{11} S_{22} - S_{21} S_{12}$

TYPICAL COMMON EMITTER SCATTERING PARAMETERS (TA = 25°C)



Coordinates in Ohms
Frequency in GHz
Vce = 10 V, Ic = 20 mA

NE41615
VCE = 10 V, IC = 5 mA

FREQUENCY (MHz)	S11		S21		S12		S22		K	MAG ¹ (dB)
	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG		
100	.86	-68	12.47	139	.03	59	.84	-25	0.496	25.220
500	.76	-154	4.15	87	.07	24	.44	-41	0.728	20.990
1000	.76	-175	2.16	62	.08	20	.42	-57	0.978	15.097
1500	.76	175	1.46	43	.09	22	.47	-73	0.833	10.025
2000	.77	167	1.08	27	.09	22	.51	-91	0.749	6.826
2500	.78	157	.83	11	.10	22	.55	-106	0.836	4.496

VCE = 10 V, IC = 10 mA

100	.79	-92	18.90	129	.02	51	.71	-35	0.876	28.176
500	.76	-165	5.11	84	.05	31	.30	-46	1.021	21.874
1000	.76	179	2.60	62	.06	34	.30	-59	0.983	15.224
1500	.76	171	1.76	44	.08	32	.35	-75	0.857	10.068
2000	.77	164	1.30	29	.09	34	.40	-91	0.800	7.202
2500	.78	155	1.01	14	.10	30	.46	-106	0.858	4.994

VCE = 10 V, IC = 20 mA

100	.75	-117	24.58	119	.01	45	.57	-45	1.035	27.696
500	.76	-172	5.80	81	.03	40	.20	-51	1.108	21.246
1000	.77	176	2.92	62	.06	44	.21	-63	0.964	15.197
1500	.77	169	1.97	46	.08	42	.27	-77	0.882	10.191
2000	.78	162	1.45	31	.09	43	.32	-94	0.837	7.335
2500	.79	151	1.13	16	.10	36	.39	-107	0.889	5.308

VCE = 10 V, IC = 30 mA

100	.73	-130	26.90	114	.01	47	.50	-49	1.983	26.423
500	.76	-175	6.05	80	.03	45	.17	-53	1.110	21.390
1000	.77	175	3.02	62	.05	48	.18	-64	0.987	15.338
1500	.78	168	2.03	46	.07	44	.25	-78	0.886	10.082
2000	.79	162	1.50	32	.09	45	.30	-95	0.840	7.297
2500	.79	150	1.16	17	.10	40	.37	-109	0.904	5.408

VCE = 10 V, IC = 50 mA

100	.73	-142	27.99	110	.01	43	.43	-50	2.052	26.429
500	.78	-178	6.03	79	.02	53	.16	-49	1.133	21.304
1000	.78	173	3.00	61	.05	51	.18	-62	0.996	15.418
1500	.79	167	2.01	46	.07	49	.24	-77	0.888	10.162
2000	.81	160	1.49	32	.08	50	.30	-94	0.858	7.351
2500	.81	151	1.16	19	.10	45	.36	-110	0.912	5.473

Note:

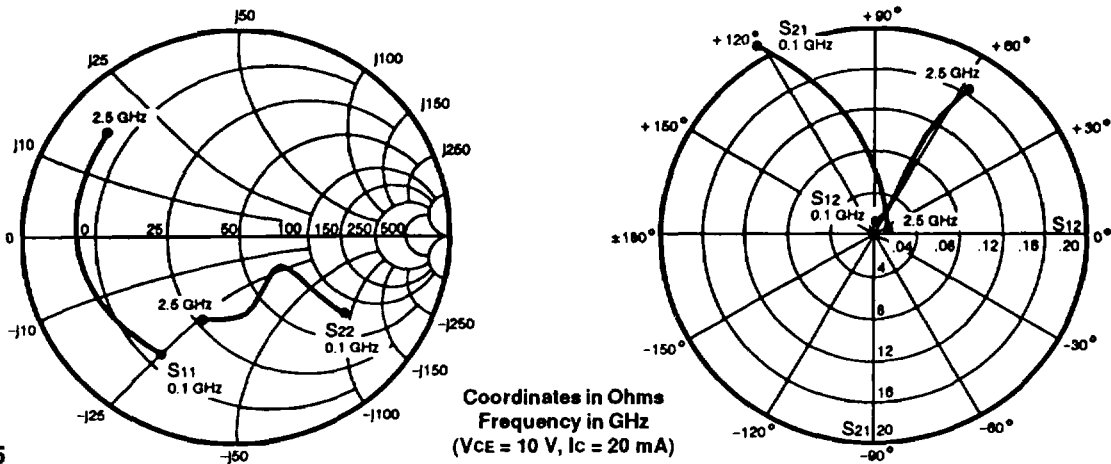
1. Gain Calculations:

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



NE416 SERIES

TYPICAL COMMON EMITTER SCATTERING PARAMETERS (TA = 25°C)



NE41635

VCE = 10 V, IC = 5 mA

FREQUENCY (MHz)	S11		S21		S12		S22		K	MAG ¹ (dB)
	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG		
100	.76	-72	11.56	140	.03	59	.85	-23	0.080	25.858
500	.75	-161	3.86	88	.06	27	.48	-38	0.154	24.098
1000	.75	176	2.00	62	.07	33	.45	-54	0.593	18.084
1500	.76	162	1.36	44	.08	44	.48	-72	1.015	13.799
2000	.77	151	1.01	31	.10	54	.52	-87	1.184	9.710
2500	.79	138	.80	17	.15	56	.51	-110	1.147	7.716

VCE = 10 V, IC = 10 mA

100	.70	-102	17.26	129	.02	53	.73	-32	0.567	33.375
500	.76	-171	4.68	85	.04	36	.36	-41	0.543	30.700
1000	.76	171	2.39	63	.06	45	.35	-56	1.245	19.444
1500	.76	161	1.61	47	.08	52	.39	-73	1.263	13.368
2000	.78	151	1.21	33	.11	58	.43	-89	1.101	11.073
2500	.78	137	.96	18	.23	63	.42	-110	1.010	9.904

VCE = 10 V, IC = 20 mA

100	.65	-125	21.75	120	.01	51	.62	-37	0.567	33.375
500	.73	-178	5.24	82	.03	52	.28	-42	0.543	30.700
1000	.73	167	2.65	61	.06	60	.26	-57	1.245	19.444
1500	.75	157	1.80	45	.09	60	.30	-74	1.263	13.368
2000	.76	147	1.35	33	.12	62	.35	-88	1.101	11.073
2500	.77	135	1.07	18	.16	58	.37	-110	1.010	9.904

VCE = 10 V, IC = 30 mA

100	.65	-137	23.60	117	.01	53	.55	-41	0.622	33.729
500	.73	179	5.45	81	.04	57	.24	-42	0.496	30.371
1000	.73	166	2.75	61	.07	63	.24	-57	0.943	21.343
1500	.74	156	1.86	45	.10	62	.28	-74	1.070	14.322
2000	.76	147	1.39	33	.13	62	.32	-88	1.026	11.707
2500	.78	136	1.10	19	.17	58	.34	-110	0.943	10.291

Note:

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