

NEC[®]**NPN MEDIUM POWER
UHF-VHF TRANSISTOR**T-31-21
**NE416
SERIES****FEATURES**

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

DESCRIPTION AND APPLICATIONS

The NE416 series of NPN transistors is one of the most versatile and widely used of NEC's 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 NE41615 has been space qualified. The series is volume produced, 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.

ABSOLUTE MAXIMUM RATINGS (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*
T _{STG}	Storage Temperature	°C	-65 to +200*

* 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°C.

NE41635 TYPICAL NOISE PARAMETERSV_{CE} = 10 V, I_C = 5 mA

FREQUENCY (MHz)	NF min (dB)	G _A /dB	OPT SOURCE	RN/50 Ω
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_{CE} = 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

PERFORMANCE SPECIFICATIONS (T_A = 25°C)

PART NUMBER EIAJ ² REGISTERED NUMBER PACKAGE CODE			NE41607 07			NE41612 NE416121 ³ 2SC2025 (GrdD) NC921 (Grd D) 12 (TO-72)			NE41615 2SC1426 (GrdCX) 15 (TO-33)			NE41635 35 (MICRO-X)		
SYMBOLS	PARAMETERS & CONDITIONS	UNITS	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX
I _{CBO}	Collector Cutoff Current at V _{CB} = 20 V, I _E = 0	μA			0.1			0.1			0.1			0.1
I _{EBO}	Emitter Current Gain at V _{EB} = 2 V, I _C = 0	μA			0.1			0.1			0.1			0.1
h _{FE}	Forward Current Gain ⁴ 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	30	100	200
C _{CB}	Collector to Base Capacitance ⁵ at V _{CB} = 5 V, I _E = 0, f = 1.0 MHz V _{CB} = 10 V, I _E = 0, f = 1.0 MHz	pF		1	2		1.3	2		1	2		1	2
R _{TH}	Thermal Resistance (j-c)	°C/W			50			50			50			50
P _T	Total Power Dissipation (T _A = 25°C)	W			.58			.50			3.5			.29

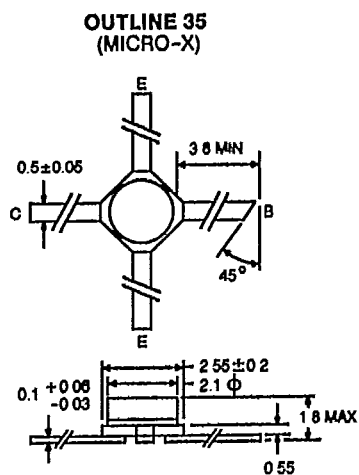
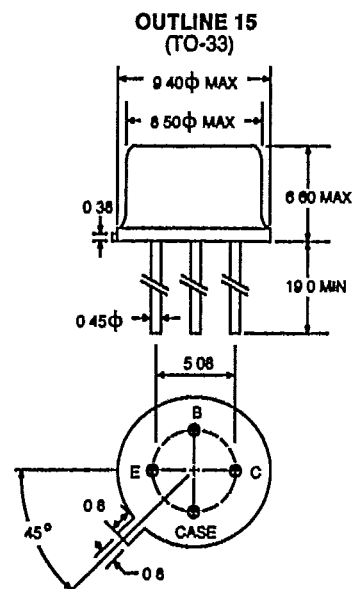
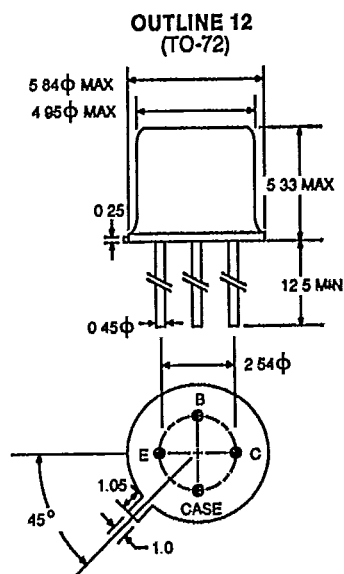
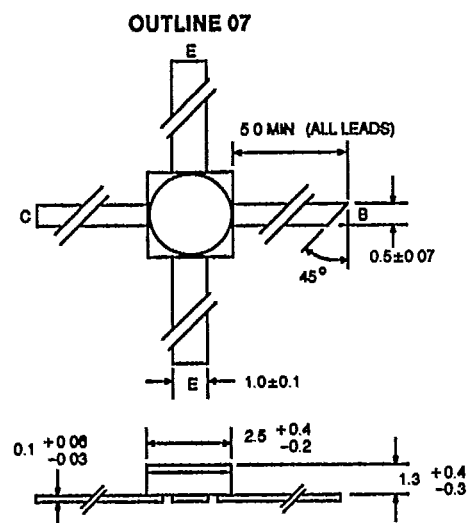
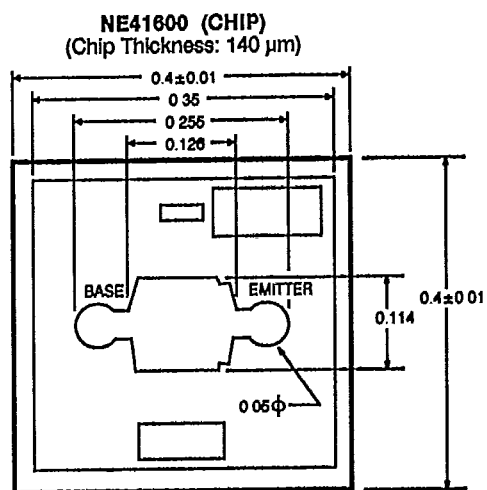
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

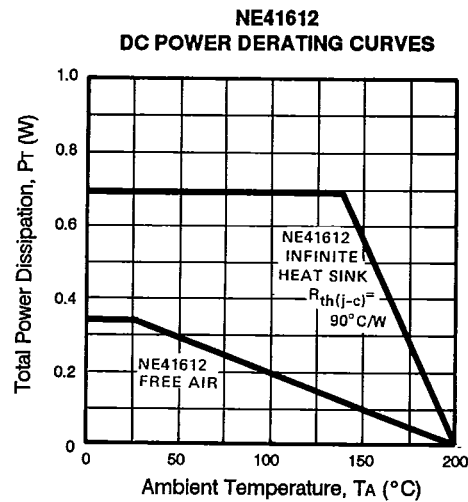
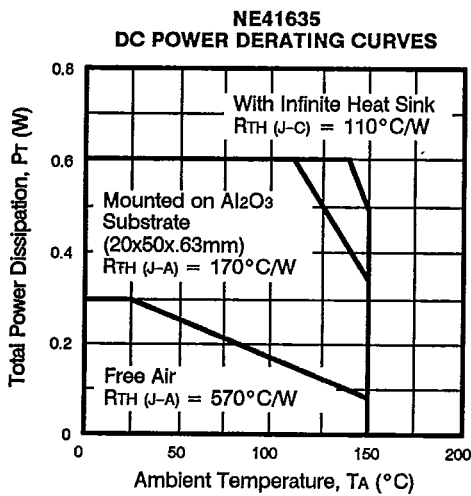
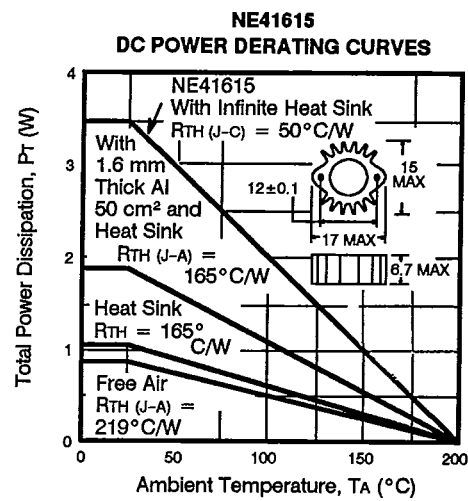
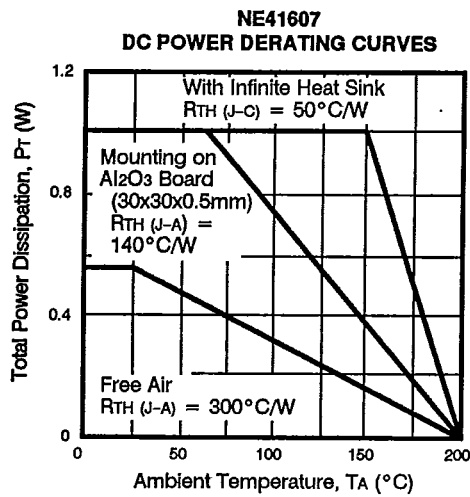
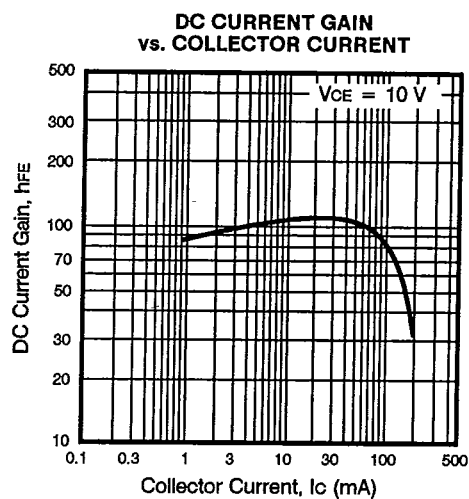
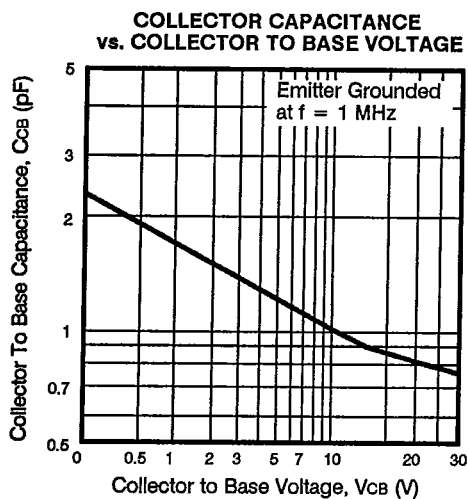
PART NUMBER EIAJ ² REGISTERED NUMBER PACKAGE CODE			NE41607 07			NE41612 NE416121 ³ 2SC2025 (GrdD) NC921 (Grd D) 12 (TO-72)			NE41615 2SC1426 (GrdCX) 15 (TO-33)			NE41635 35 (MICRO-X)		
SYMBOLS	PARAMETERS & CONDITIONS	UNITS	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX
f _T	Gain Bandwidth Product at V _{CE} = 5 V, I _C = 25 mA V _{CE} = 10 V, I _C = 50 mA	GHz GHz	2	3.5		1.5	2.7		2	3.5		2	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	7	16 9.5			13 8			13 8		7	16 9.5	
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 V _{CE} = 5 V, I _C = 2 mA, R _G = 200 Ω f = 70 MHz (NE41612-1)	dB dB dB dB		1.2 1.5 3.5			2.3 2.8 5	4		1.4 1.5 3.7			1.5 3.5	
MAG	Maximum Available Gain ⁶ at V _{CE} = 10 V, I _C = 30 mA f = 0.5 GHz f = 1.0 GHz	dB dB		20 14			15.5 10			15.5 10			21 14	

Notes:

- Maximum Storage Temperature (T_{STG}) for the NE41635 is -65°C ~ 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°C.
- Electronic Industrial Association of Japan.
- NE41612 - 1 (NC921) is selected for low noise.
- Pulse measurement Duty Cycle < 2%, PW < 30 ns.
- C_{CB} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter terminal shall be connected to the guard terminal.

$$6. \text{ MAG} = |S_{21E}|^2 \frac{1}{|1 - S_{11E}|^2} \cdot \frac{1}{|1 - S_{22E}|^2}$$

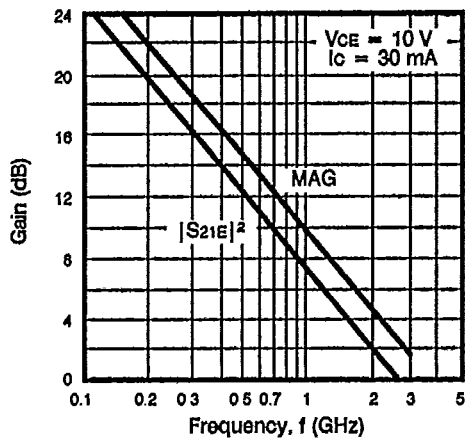
NE416 SERIES**OUTLINE DIMENSIONS** (Units in mm)

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

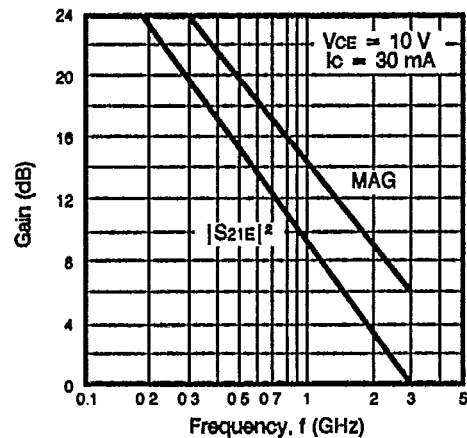
NE416 SERIES

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

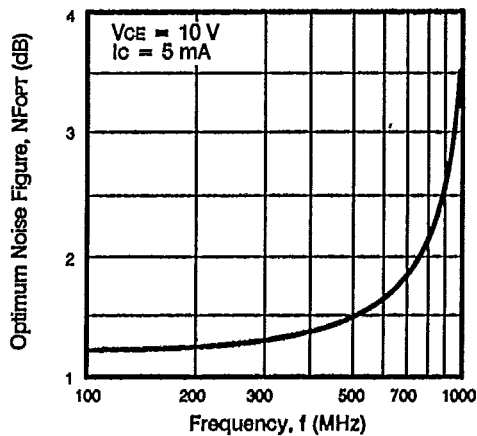
NE41612 AND NE41615
FORWARD INSERTION GAIN
AND MAXIMUM AVAILABLE GAIN
vs. FREQUENCY



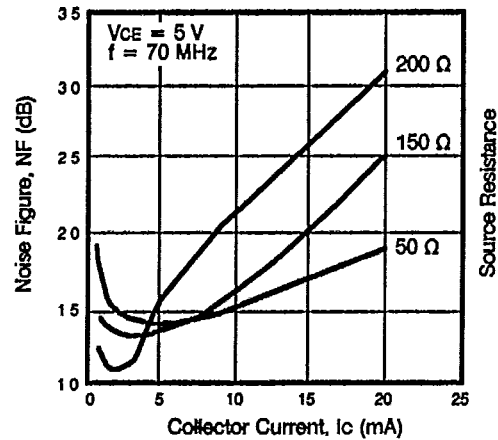
NE41607
FORWARD INSERTION GAIN AND
MAXIMUM AVAILABLE GAIN
vs. FREQUENCY



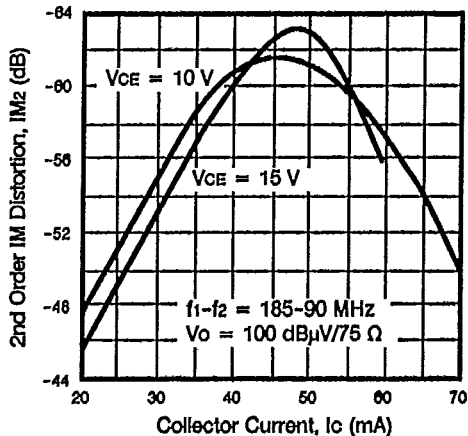
NE41607
NOISE FIGURE vs. FREQUENCY



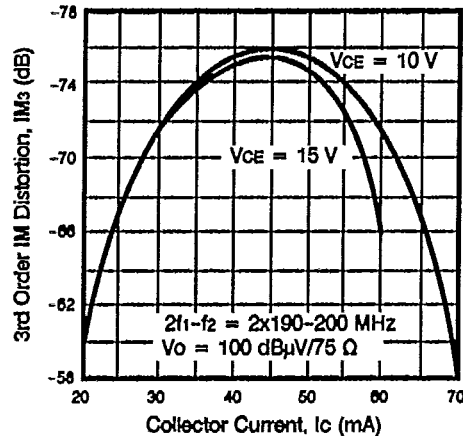
NE41612-1
NOISE FIGURE vs.
COLLECTOR CURRENT AND
SOURCE RESISTANCE



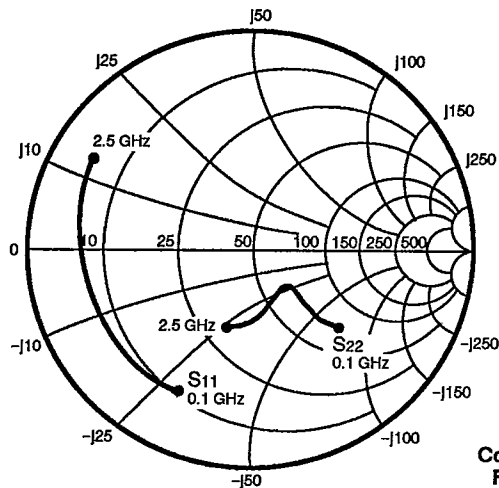
NE41615
SECOND ORDER IM DISTORTION
vs. COLLECTOR CURRENT



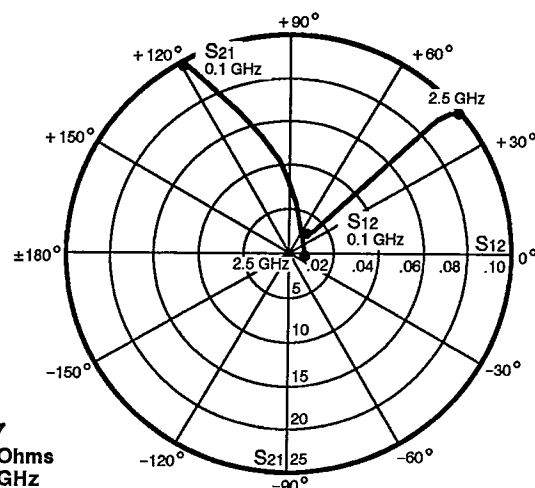
NE41615
THIRD ORDER IM DISTORTION
vs. COLLECTOR CURRENT



TYPICAL COMMON EMITTER SCATTERING PARAMETERS



NE41607
Coordinates in Ohms
Frequency in GHz
($V_{CE} = 10\text{ V}$, $I_C = 20\text{ mA}$)

**S-MAGN AND ANGLES:** $V_{CE} = 10\text{ V}$, $I_C = 5\text{ mA}$

FREQUENCY (MHz)

	S ₁₁		S ₂₁		S ₁₂		S ₂₂	
100	.86	-68	12.47	139	.03	59	.84	-25
500	.76	-154	4.15	87	.07	24	.44	-41
1000	.76	-175	2.16	62	.08	20	.42	-57
1500	.76	175	1.46	43	.09	22	.47	-73
2000	.77	167	1.08	27	.09	22	.51	-91
2500	.78	157	.83	11	.10	22	.55	-106

 $V_{CE} = 10\text{ V}$, $I_C = 10\text{ mA}$

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

 $V_{CE} = 10\text{ V}$, $I_C = 20\text{ mA}$

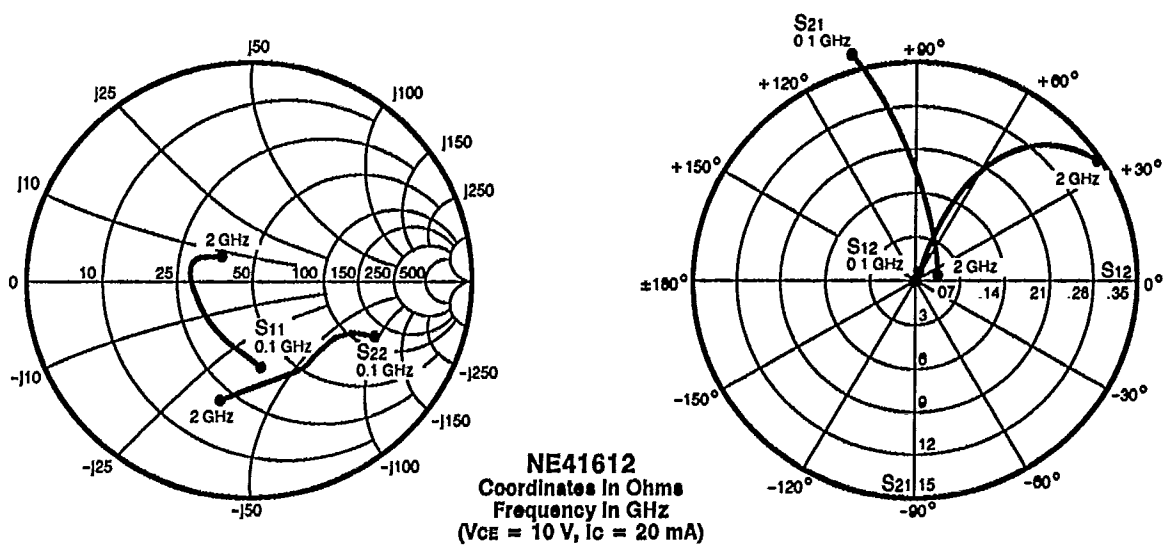
100	.75	-117	24.58	119	.01	45	.57	-45
500	.76	-172	5.80	81	.03	40	.20	-51
1000	.77	176	2.92	62	.06	44	.21	-63
1500	.77	169	1.97	46	.08	42	.27	-77
2000	.78	162	1.45	31	.09	43	.32	-94
2500	.79	151	1.13	16	.10	36	.39	-107

 $V_{CE} = 10\text{ V}$, $I_C = 30\text{ mA}$

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

 $V_{CE} = 10\text{ V}$, $I_C = 50\text{ mA}$

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

NE416 SERIES**TYPICAL COMMON EMITTER SCATTERING PARAMETERS****S-MAGN AND ANGLES:**

VCE = 5 V, IC = 2 mA

FREQUENCY (MHz)

	S11		S21		S12		S22	
100	.83	-52	6.06	141	.05	58	.89	-20
200	.69	-87	4.45	118	.09	49	.76	-31
500	.52	-143	2.25	81	.12	39	.59	-46
1000	.49	172	1.31	49	.16	54	.55	-69
1500	.44	139	.97	28	.25	59	.59	-92
2000	.35	108	.82	12	.36	48	.60	-115

VCE = 10 V, IC = 5 mA

	S11		S21		S12		S22	
100	.68	-60	10.41	132	.03	62	.80	-22
200	.51	-95	6.94	110	.06	54	.65	-30
500	.37	-148	3.24	79	.10	57	.53	-40
1000	.34	170	1.79	52	.17	61	.51	-59
1500	.30	145	1.32	30	.25	58	.55	-82
2000	.22	122	1.05	9	.32	46	.60	-104

VCE = 10 V, IC = 10 mA

	S11		S21		S12		S22	
100	.52	-73	13.86	122	.02	62	.69	-25
200	.38	-105	8.38	102	.05	59	.56	-31
500	.29	-155	3.71	77	.11	63	.46	-39
1000	.27	169	2.02	51	.19	61	.45	-57
1500	.24	149	1.48	30	.26	53	.50	-80
2000	.17	135	1.18	9	.32	41	.56	-100

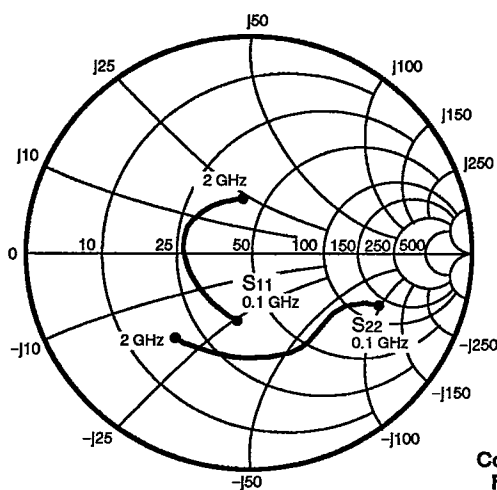
VCE = 10 V, IC = 20 mA

	S11		S21		S12		S22	
100	.39	-83	16.25	114	.02	62	.60	-27
200	.29	-114	9.23	98	.04	65	.49	-30
500	.25	-159	3.97	75	.11	67	.42	-38
1000	.24	168	2.15	51	.20	60	.41	-56
1500	.20	152	1.57	30	.28	51	.46	-78
2000	.14	145	1.24	9	.33	37	.53	-98

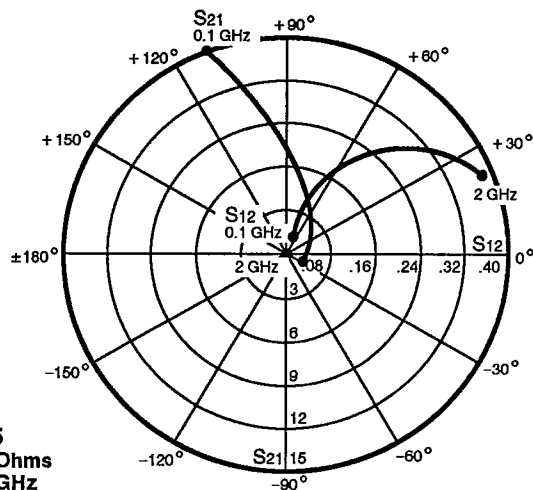
VCE = 10 V, IC = 30 mA

	S11		S21		S12		S22	
100	.34	-89	16.82	111	.02	65	.56	-27
200	.26	-119	9.37	96	.04	66	.47	-28
500	.24	-162	4.00	74	.11	68	.41	-37
1000	.23	167	2.16	51	.20	61	.41	-56
1500	.20	152	1.57	30	.28	51	.45	-78
2000	.14	145	1.24	8	.33	36	.52	-98

TYPICAL COMMON EMITTER SCATTERING PARAMETERS



NE41615
Coordinates in Ohms
Frequency in GHz
(VCE = 10 V, IC = 20 mA)



S-MAGN AND ANGLES:

VCE = 10 V, IC = 5 mA

FREQUENCY (MHz)

	S11		S21		S12		S22	
100	.59	-74	9.98	126	.03	58	.78	-22
200	.46	-112	6.28	103	.05	52	.66	-30
500	.39	-160	2.91	72	.09	57	.59	-46
1000	.37	164	1.71	39	.17	57	.62	-78
1500	.36	133	1.30	10	.27	46	.62	-109
2000	.31	91	1.07	-16	.38	31	.59	-136

VCE = 10 V, IC = 10 mA

	S11		S21		S12		S22	
100	.42	-89	13.14	116	.02	60	.68	-25
200	.33	-124	7.57	97	.04	61	.57	-29
500	.31	-165	3.33	70	.10	65	.53	-46
1000	.31	164	1.93	39	.19	55	.56	-78
1500	.31	135	1.47	10	.28	41	.56	-107
2000	.26	96	1.20	-16	.38	27	.54	-133

VCE = 10 V, IC = 20 mA

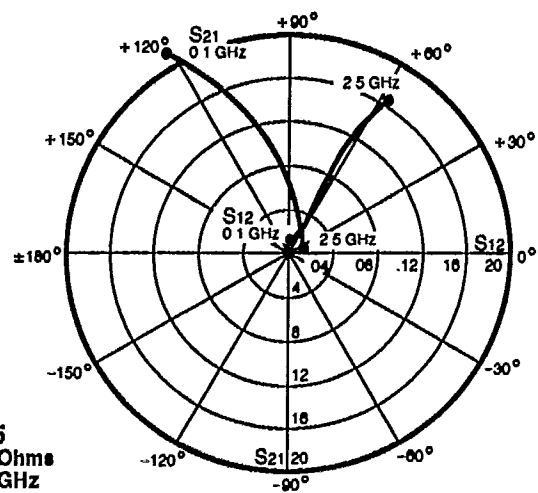
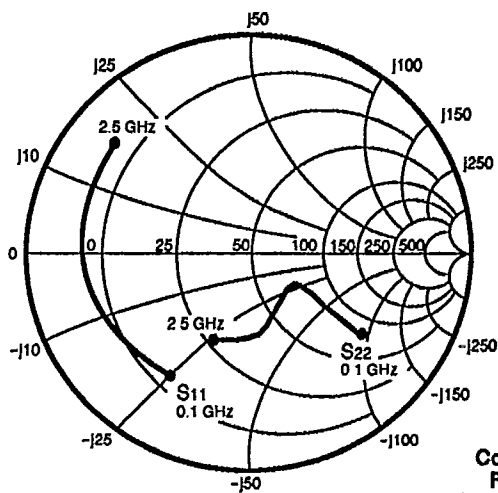
	S11		S21		S12		S22	
100	.29	-104	15.31	110	.02	63	.59	-26
200	.25	-135	8.44	93	.04	68	.51	-18
500	.27	-167	3.64	69	.11	67	.48	-46
1000	.28	165	2.09	39	.20	53	.51	-78
1500	.27	138	1.57	11	.29	39	.52	-106
2000	.22	98	1.29	-16	.38	23	.50	-131

VCE = 10 V, IC = 30 mA

	S11		S21		S12		S22	
100	.24	-112	16.22	107	.01	69	.56	-25
200	.22	-140	8.77	92	.04	73	.49	-28
500	.25	-168	3.76	69	.11	67	.46	-46
1000	.26	167	2.14	39	.21	53	.49	-78
1500	.26	139	1.61	11	.30	38	.50	-106
2000	.21	100	1.32	-15	.38	22	.48	-130

VCE = 10 V, IC = 50 mA

	S11		S21		S12		S22	
100	.19	-126	16.89	104	.01	72	.53	-25
200	.20	-148	8.99	90	.04	73	.47	-27
500	.24	-170	3.83	68	.11	68	.45	-46
1000	.26	166	2.18	39	.21	52	.48	-78
1500	.26	139	1.63	11	.30	37	.48	-106
2000	.20	99	1.34	-16	.38	21	.47	-129

NE416 SERIES**TYPICAL COMMON EMITTER SCATTERING PARAMETERS****S-MAGN AND ANGLES:**

VCE = 10 V, IC = 5 mA

FREQUENCY (MHz)

	S11		S21		S12		S22	
100	.76	-72	11.56	140	.03	59	.85	-23
500	.75	-161	3.86	88	.06	27	.48	-38
1000	.75	176	2.00	62	.07	33	.45	-54
1500	.76	162	1.36	44	.08	44	.48	-72
2000	.77	151	1.01	31	.10	54	.52	-87
2500	.79	138	.80	17	.15	56	.51	-110

VCE = 10 V, IC = 10 mA

	S11		S21		S12		S22	
100	.70	-102	17.26	129	.02	53	.73	-32
500	.76	-171	4.68	85	.04	36	.36	-41
1000	.76	171	2.39	63	.06	45	.35	-56
1500	.76	161	1.61	47	.08	52	.39	-73
2000	.78	151	1.21	33	.11	58	.43	-89
2500	.78	137	.96	18	.23	63	.42	-110

VCE = 10 V, IC = 20 mA

	S11		S21		S12		S22	
100	.65	-125	21.75	120	.01	51	.62	-37
500	.73	-178	5.24	82	.03	52	.28	-42
1000	.73	167	2.65	61	.06	60	.26	-57
1500	.75	157	1.80	45	.09	60	.30	-74
2000	.76	147	1.35	33	.12	62	.35	-88
2500	.77	135	1.07	18	.16	58	.37	-110

VCE = 10 V, IC = 30 mA

	S11		S21		S12		S22	
100	.65	-137	23.60	117	.01	53	.55	-41
500	.73	179	5.45	81	.04	57	.24	-42
1000	.73	166	2.75	61	.07	63	.24	-57
1500	.74	156	1.86	45	.10	62	.28	-74
2000	.76	147	1.39	33	.13	62	.32	-88
2500	.78	136	1.10	19	.17	58	.34	-110