NEC®

T-31-21

NPN MEDIUM POWER UHF-VHF TRANSISTOR | 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 NECs 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_{CBO}	Collector to Base Voltage	V	35
V_{CEO}	Collector to Emitter Voltage	V	18
V_{EBO}	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 PARAMETERS

FREQUENCY (MHz)	NF min (dB)	G_A/dB	OPT SOURCE	RN/50 Ω
VCE = 10 V, IC = 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
VCE = 10 V, IC = 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}	Emmitter 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)

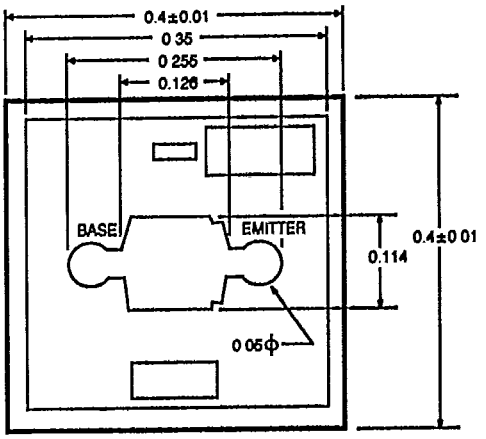
PART NUMBER EIAJ[2] REGISTERED NUMBER PACKAGE CODE			NE41607 07			NE41612 NE416121[3] 2SC2025 (GrdD) NC921 (Grd D) 12 (TO–72)			NE41615 2SC1426 (GrdCX) 15 (TO–33)			NE41635 35 (MICRO-X)		
SYMBOLS	PARAMETERS & CONDITIONS	UNITS	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX
f_T	Gain Bandwidth Product 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 1			 2.3 2.8 5 1	 4 1.2		 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:

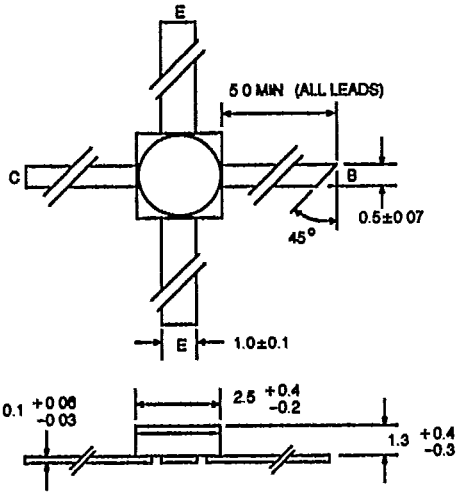
1. Maximum Storage Temperature (T_{STG}) for the NE41635 is -65°C ~ 150°C. The leads of the NE41635 are Sn plated and may tarnish above 150°C. Once soldered into a circuit, the unit can be stored at 200°C.
2. Electronic Industrial Association of Japan.
3. NE41612 – 1 (NC921) is selected for low noise.
4. Pulse measurement Duty Cycle<2%, PW <30 ns.
5. C_{CB} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter terminal shall be connected to the guard terminal.
6. $MAG = |S_{21E}|^2 \frac{1}{|1 - S_{11E}|^2} \cdot \frac{1}{|1 - S_{22E}|^2}$

OUTLINE DIMENSIONS (Units in mm)

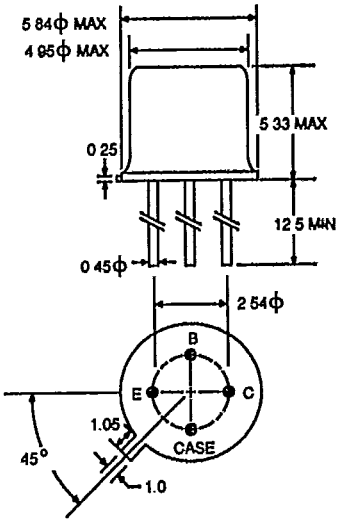
NE41600 (CHIP)
(Chip Thickness: 140 µm)



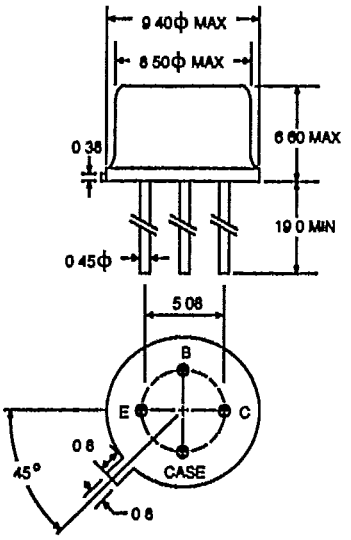
OUTLINE 07



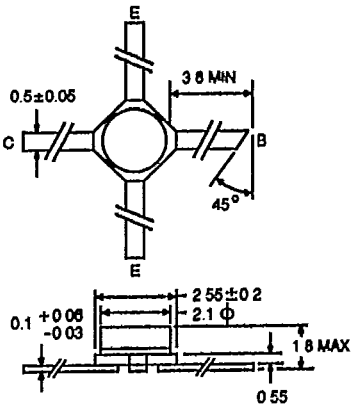
OUTLINE 12
(TO-72)



OUTLINE 15
(TO-33)

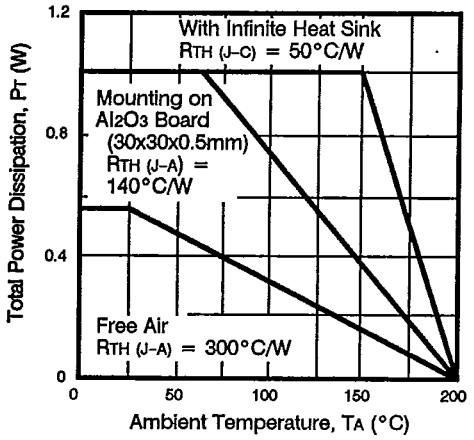


OUTLINE 35
(MICRO-X)

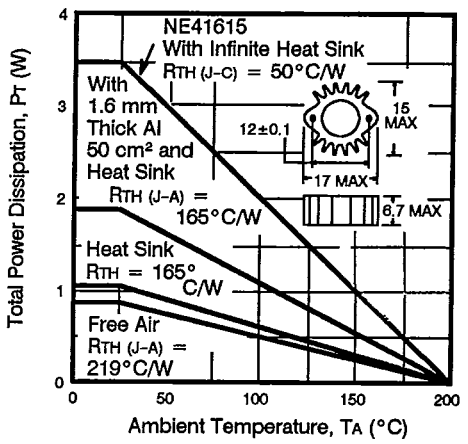


TYPICAL DEVICE CHARACTERISTICS (T_A = 25°C)

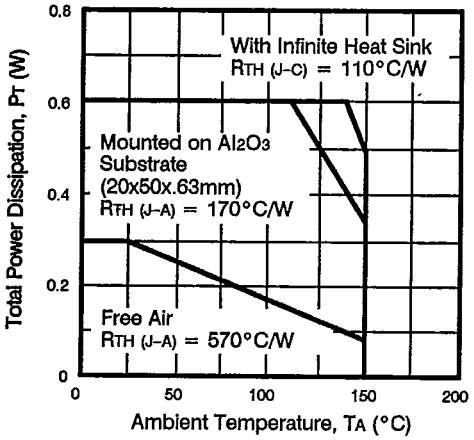
NE41607
DC POWER DERATING CURVES



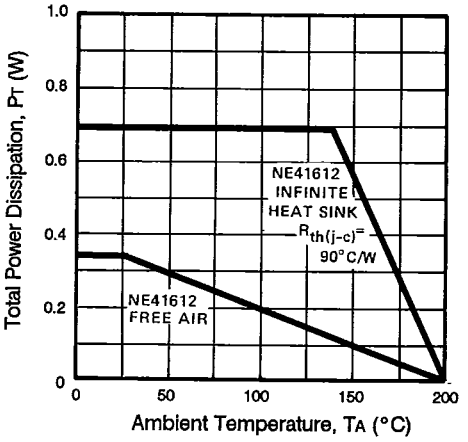
NE41615
DC POWER DERATING CURVES



NE41635
DC POWER DERATING CURVES

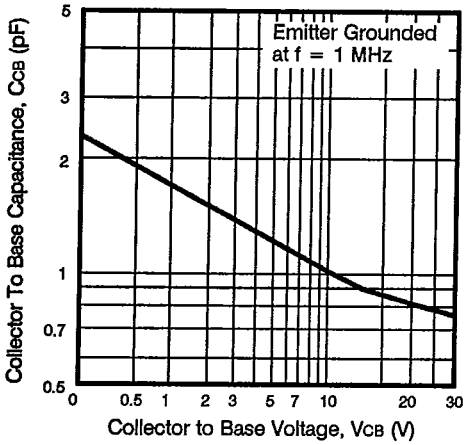


NE41612
DC POWER DERATING CURVES

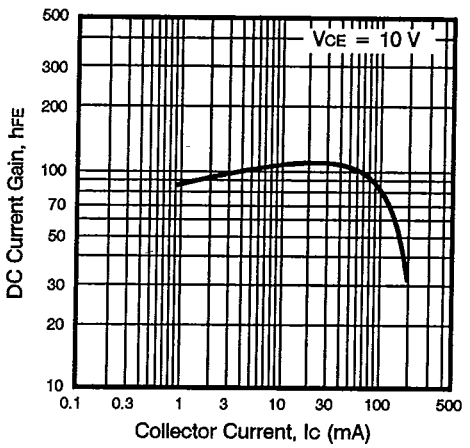


TYPICAL PERFORMANCE CHARACTERISTICS (T_A = 25°C)

COLLECTOR CAPACITANCE
vs. COLLECTOR TO BASE VOLTAGE

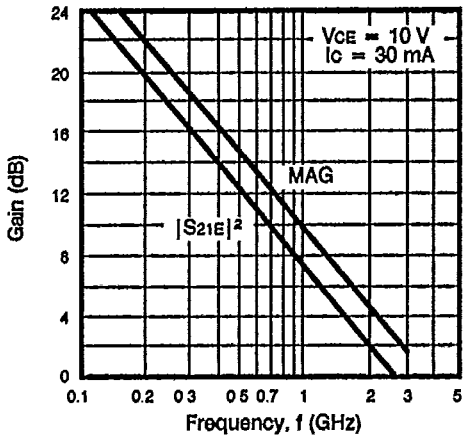


DC CURRENT GAIN
vs. COLLECTOR CURRENT

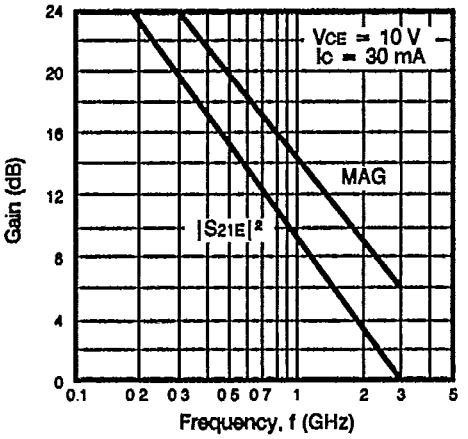


TYPICAL PERFORMANCE CHARACTERISTICS (T_A = 25°C)

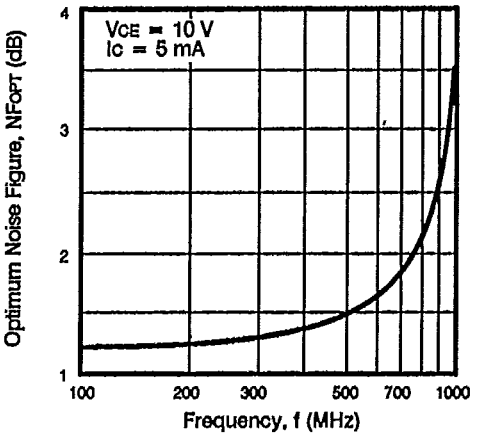
NE41612 AND NE41615 FORWARD INSERTION GAIN AND MAXIMUM AVAILABLE GAIN vs. FREQUENCY



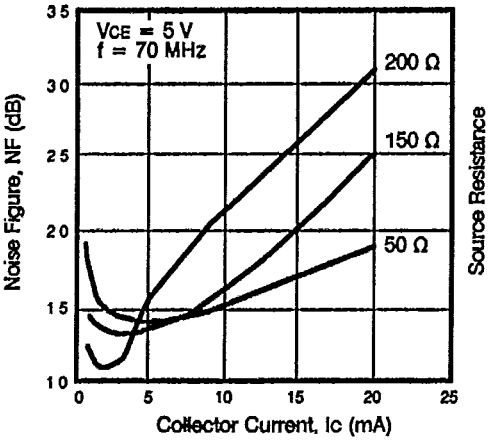
NE41607 FORWARD INSERTION GAIN AND MAXIMUM AVAILABLE GAIN vs. FREQUENCY



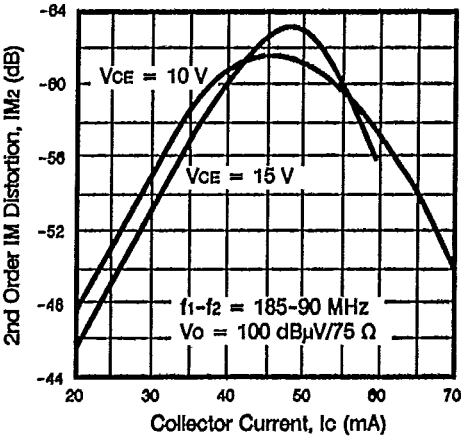
NE41607 NOISE FIGURE vs. FREQUENCY



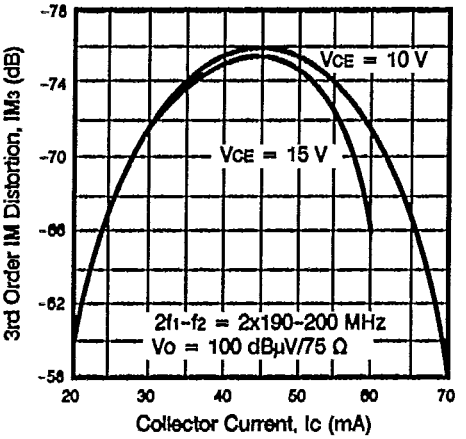
NE41612-1 NOISE FIGURE vs. COLLECTOR CURRENT AND SOURCE RESISTANCE



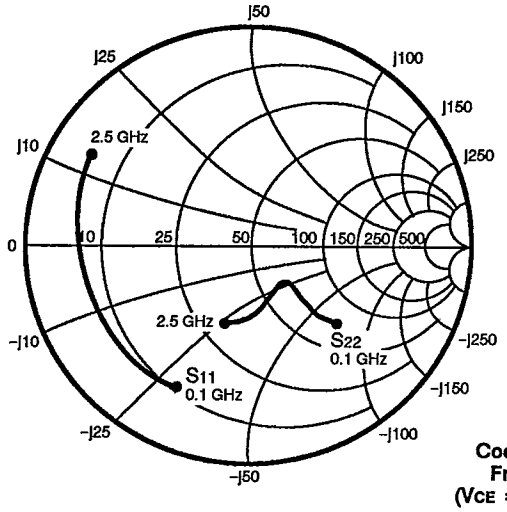
NE41615 SECOND ORDER IM DISTORTION vs. COLLECTOR CURRENT

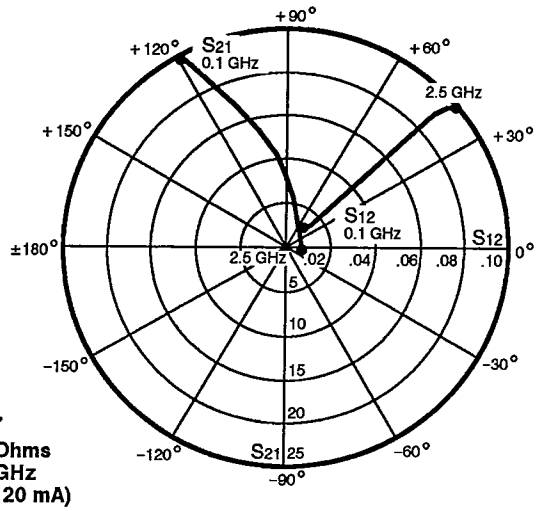


NE41615 THIRD ORDER IM DISTORTION vs. COLLECTOR CURRENT



TYPICAL COMMON EMITTER SCATTERING PARAMETERS





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

S-MAGN AND ANGLES:

VCE = 10 V, IC = 5 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

VCE = 10 V, IC = 10 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

VCE = 10 V, IC = 20 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

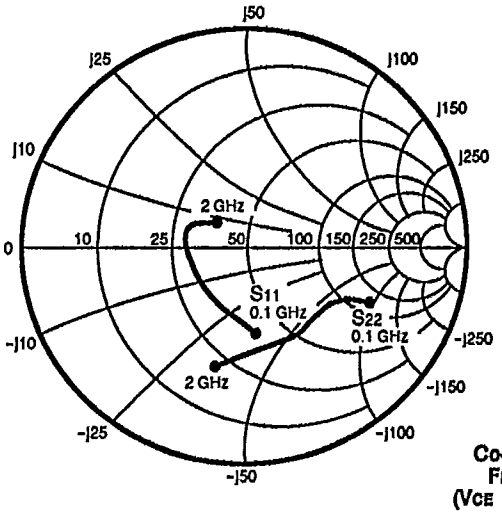
VCE = 10 V, IC = 30 mA

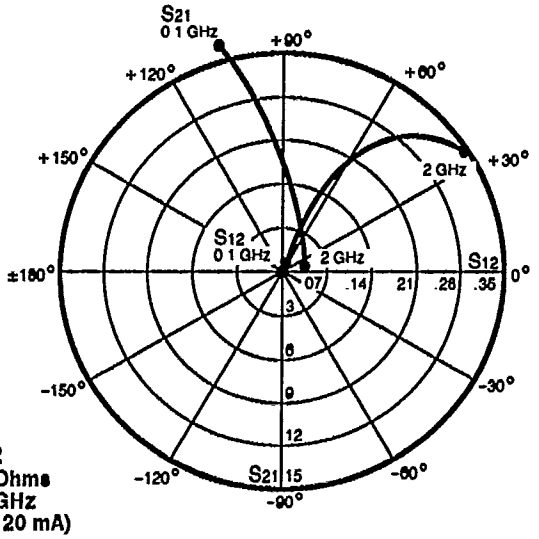
100	.73	-130	26.90	114	.01	47	.50	-49
500	.76	-175	6.05	80	.03	45	.17	-53
1000	.77	175	3.02	62	.05	48	.18	-64
1500	.78	168	2.03	46	.07	44	.25	-78
2000	.79	162	1.50	32	.09	45	.30	-95
2500	.79	150	1.16	17	.10	40	.37	-109

VCE = 10 V, IC = 50 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

TYPICAL COMMON EMITTER SCATTERING PARAMETERS





NE41612
Coordinates in Ohms
Frequency in GHz
(V_{CE} = 10 V, I_C = 20 mA)

S-MAGN AND ANGLES:

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

FREQUENCY (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
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

V_{CE} = 10 V, I_C = 5 mA

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

V_{CE} = 10 V, I_C = 10 mA

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

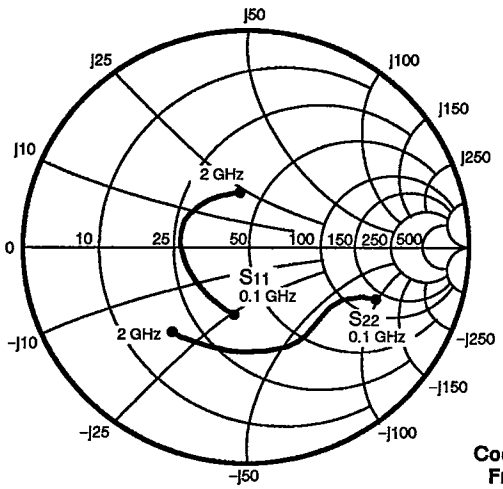
V_{CE} = 10 V, I_C = 20 mA

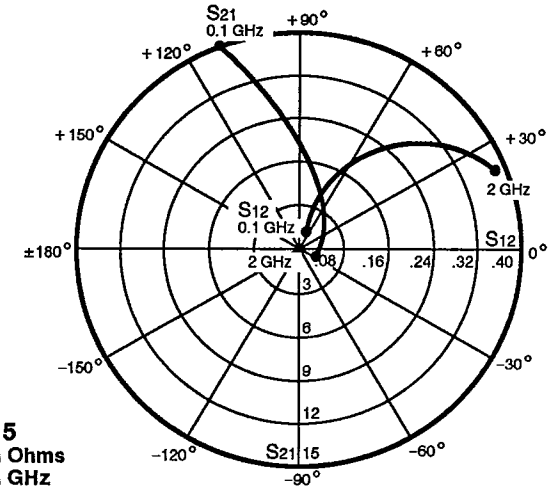
100	.39	-83	16.25	114	.02	62	.60	-27
200	.29	-114	9.23	98	.04	65	.49	-30
500	.25	-159	3.97	75	.11	67	.42	-38
1000	.24	168	2.15	51	.20	60	.41	-56
1500	.20	152	1.57	30	.28	51	.46	-78
2000	.14	145	1.24	9	.33	37	.53	-98

V_{CE} = 10 V, I_C = 30 mA

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
(V_{CE} = 10 V, I_C = 20 mA)

S-MAGN AND ANGLES:

V_{CE} = 10 V, I_C = 5 mA

FREQUENCY (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
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

V_{CE} = 10 V, I_C = 10 mA

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

V_{CE} = 10 V, I_C = 20 mA

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

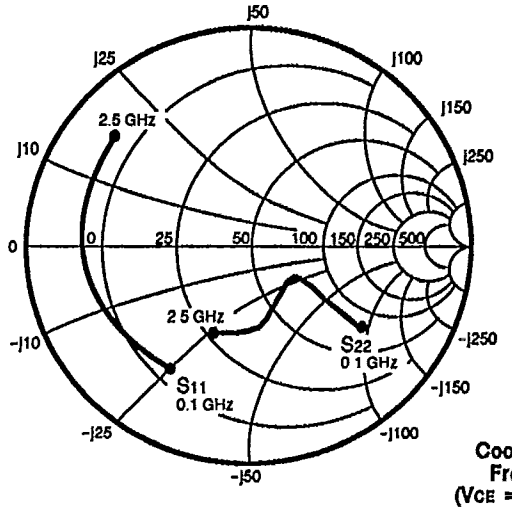
V_{CE} = 10 V, I_C = 30 mA

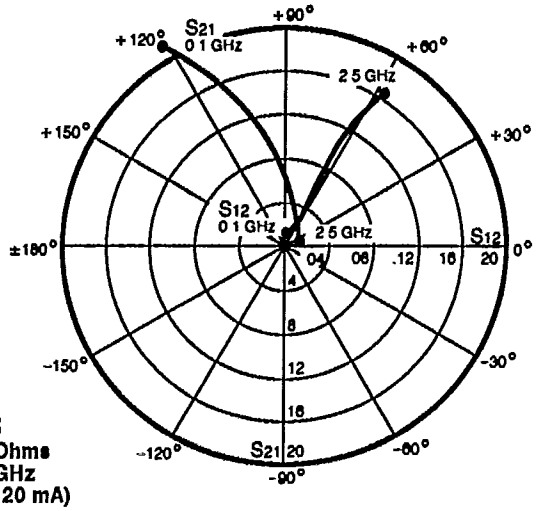
100	.24	-112	16.22	107	.01	69	.56	-25
200	.22	-140	8.77	92	.04	73	.49	-28
500	.25	-168	3.76	69	.11	67	.46	-46
1000	.26	167	2.14	39	.21	53	.49	-78
1500	.26	139	1.61	11	.30	38	.50	-106
2000	.21	100	1.32	-15	.38	22	.48	-130

V_{CE} = 10 V, I_C = 50 mA

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

TYPICAL COMMON EMITTER SCATTERING PARAMETERS





NE41635
Coordinates in Ohms
Frequency in GHz
(V_{CE} = 10 V, I_C = 20 mA)

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

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

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

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