NEC®

NPN SILICON HIGH FREQUENCY TRANSISTOR

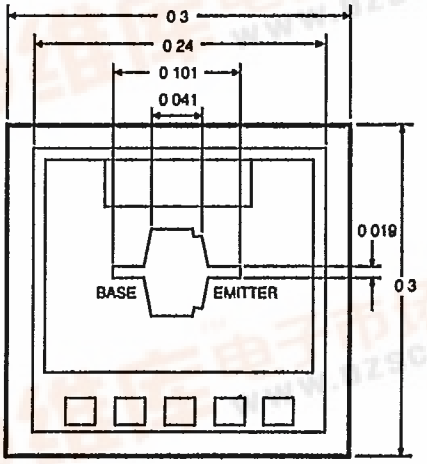
NE64500
NE64508
NE64535
NE64587

FEATURES

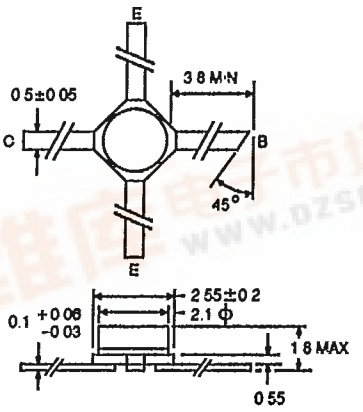
- **HIGH fT**
  fT = 8.5 GHz
- **LOW NOISE FIGURE**
  1.3 dB at 1.5 GHz
  1.6 dB at 2 GHz
- **HIGH ASSOCIATED GAIN**
  14 dB at 1.5 GHz
  12 dB at 2 GHz
- **SPACE QUALIFIED**

OUTLINE DIMENSIONS (Units in mm)

NE64500 (CHIP)
(Chip Thickness: 160±20 µm)



OUTLINE 35

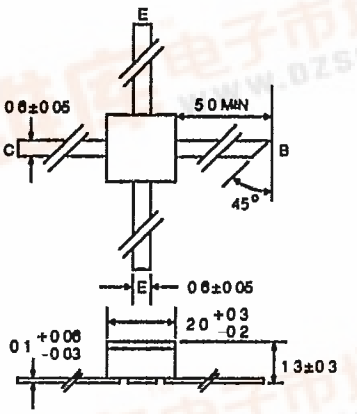


DESCRIPTION AND APPLICATIONS

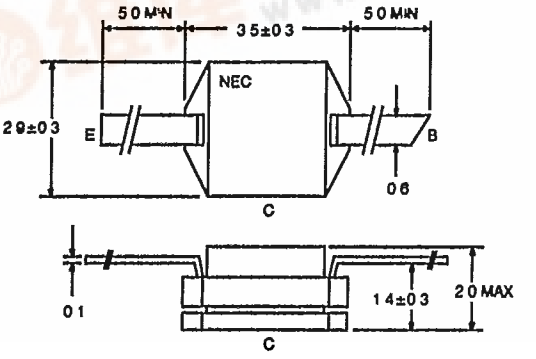
The NE645 series of NPN silicon transistors is designed for low-noise amplifier and medium power oscillator applications. The NE645 series employs a new NEC proprietary fabrication technique which provides excellent noise figures at high currents, resulting in superior associated gains and a very wide dynamic range. The NE645 is available in a chip form or three rugged hermetically sealed strip-line packages. Reliability is assured by quality control and test procedures patterned after MIL-S-19500 and MIL-STD-750.

The NE64500 (chip) employs arsenic doped emitters and NEC's reliable Pt/Si-Ti-Pt-Au metallization system. The NE64535 (MICRO-X) is a low cost, hermetically sealed package designed for large volume industrial and military microwave products. The NE64508 is in a low-loss, hi-rel package capable of meeting the rigors of space qualification. The NE64587 is in a common collector configuration suitable for oscillator applications up to 10 GHz.

OUTLINE 08



OUTLINE 87



PERFORMANCE SPECIFICATIONS (T_A = 25°C)

PART NUMBER EIAJ[1] REGISTERED NUMBER PACKAGE OUTLINE			NE64500 00 (CHIP)			NE64508 2SC2273 08			NE64535 2SC2585 35 (MICRO-X)			NE64587 87		
SYMBOLS	PARAMETERS AND CONDITIONS	UNITS	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX
f_T	Gain Bandwidth Product at V_{CE} = 8 V, I_C = 20 mA	GHz		8.5			8.5			8.5			8.5	
$\|S_{21E}\|^2$	Insertion Power Gain at V_{CE} = 8 V, I_C = 20 mA, f = 1 GHz f = 2 GHz f = 4 GHz	dB dB dB	10	18 12 6.5		10	18 12 6.5		10	18 11 6.5				
NF_{MIN}	Minimum Noise Figure[2] at V_{CE} = 8 V, I_C = 7 mA, f = 0.5 GHz f = 1.5 GHz f = 2 GHz	dB dB dB		 1.6			0.9 1.3 1.6	2		0.9 1.4 1.6	2.5			
G_A	Associated Gain at V_{CE} = 8 V, I_C = 7 mA, f = 1.5 GHz f = 2 GHz	dB dB	11	14 12		11	14 12		10	13 11				
MAG	Maximum Available Gain[3] at V_{CE} = 8 V, I_C = 10 mA, f = 2 GHz f = 4 GHz	dB dB		16			16 11			15 10				
P_{OSC}	Oscillator Output Power at V_{CE} = 10 V, I_C = 40 mA, f = 6 GHz	mW		110									110	

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

PART NUMBER EIAJ[1] REGISTERED NUMBER PACKAGE OUTLINE			NE64500 00 (CHIP)			NE64508 2SC2273 08			NE64535 2SC2585 35 (MICRO-X)			NE64587 87		
SYMBOLS	PARAMETERS AND CONDITIONS	UNITS	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX
I_{CBO}	Collector Cutoff Current at V_{CB} = 8 V, I_E = 0	µA			0.1			0.1			0.1			0.1
I_{EBO}	Emitter Cutoff Current at V_{EB} = 1 V, I_C = 0	µA			1			1			1			1
h_{FE}	Forward Current Gain at V_{CE} = 8 V, I_C = 7 mA		50	100	250	50	100	250	50	100	250	50	100	250
C_{CB}	Collector to Base Capacitance[4] at V_{CB} = 10 V, I_E = 0, f = 1 MHz	pF		0.2	0.6		0.2	0.6		0.2	0.6		0.2	0.6
R_{TH}	Thermal Resistance (Junction-to-Case)	°C/W			75			85			85			75
P_T	Total Power Dissipation[5]	mW			400			400			400			400

Notes:
1. Electronic Industrial Association of Japan.
2. Input and output are tuned for optimum noise figure.
3. Maximum Available Gain (MAG) is calculated from the device S-Parameters using the equation,

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

4. C_{CB} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter terminal shall be connected to the guard terminal.
5. The Case Temperature, Tc, when measuring Total Power Dissipation for the following devices are:
   NE64535 – Tc = 166°C
   NE64508 – Tc = 150°C
   NE64587 – Tc = 170°C

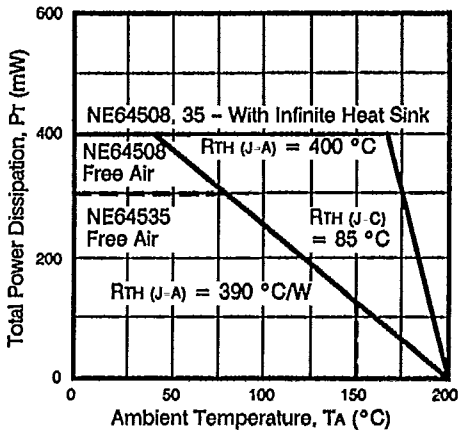
ABSOLUTE MAXIMUM RATINGS (T_A = 25°C)

SYMBOLS	PARAMETERS	UNITS	RATINGS
V_{CBO}	Collector to Base Voltage	V	25
V_{CEO}	Collector to Emitter Voltage	V	12
V_{EBO}	Emitter to Base Voltage*	V	1.5
I_C	Collector Current	mA	65
T_J	Junction Temperature	°C	200
T_{STG}	Storage Temperature	°C	-65 to +200**

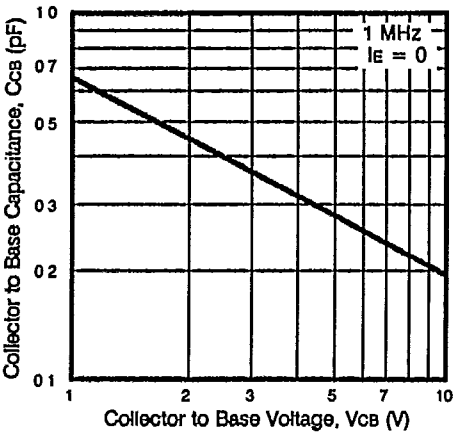
*V_{EBO} rating for NE64500 and NE64587 is 3 V.
**T_{STG} for NE64535 is -65°C to 150°C because leads are Sn plated and may tarnish above 150°C. Once soldered into a circuit, the unit can be stored at 200°C.

TYPICAL DEVICE CHARACTERISTICS (T_A = 25°C)

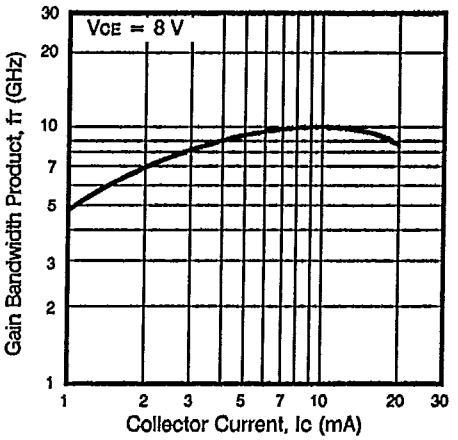
POWER DERATING CURVE



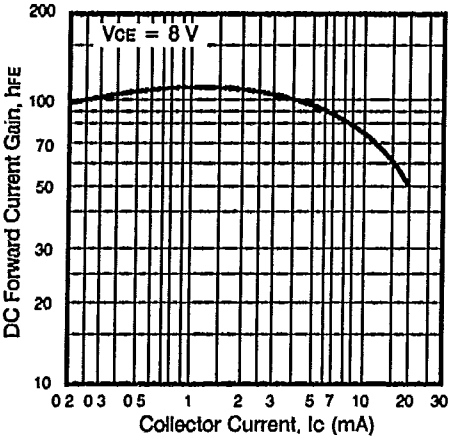
CAPACITANCE vs. COLLECTOR TO BASE VOLTAGE



GAIN BANDWIDTH PRODUCT vs. COLLECTOR CURRENT

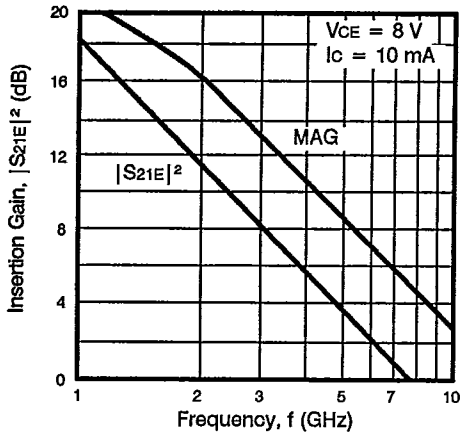


DC CURRENT GAIN vs. COLLECTOR CURRENT

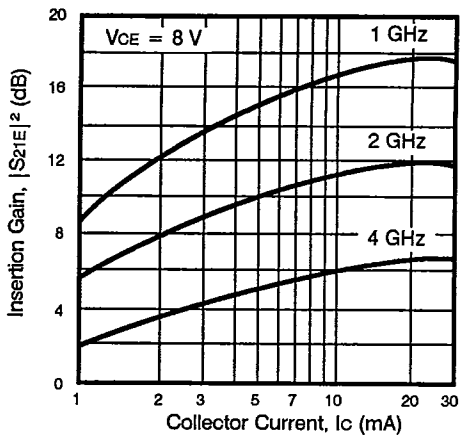


TYPICAL PERFORMANCE CHARACTERISTICS (TA = 25°C)

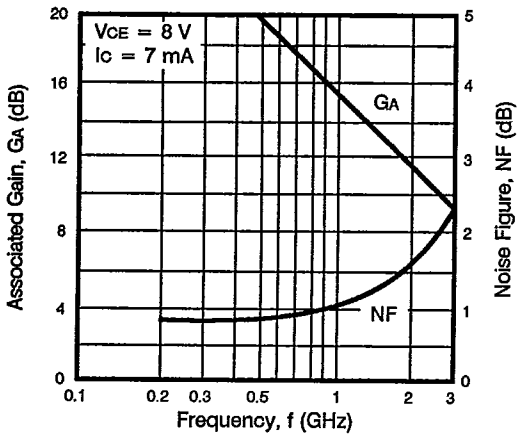
INSERTION GAIN vs. FREQUENCY



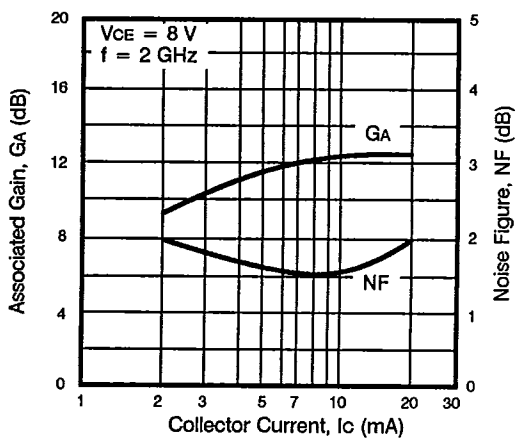
INSERTION GAIN vs. COLLECTOR CURRENT



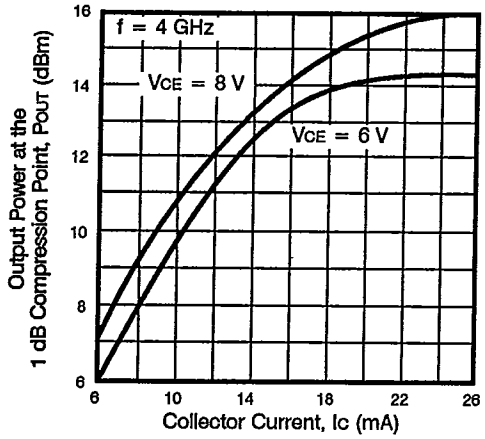
ASSOCIATED GAIN AND OPTIMUM NOISE FIGURE vs. FREQUENCY



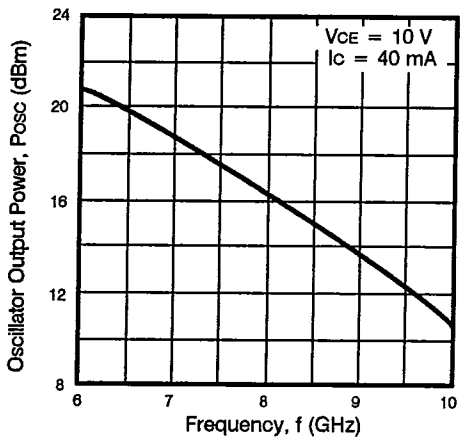
ASSOCIATED GAIN AND OPTIMUM NOISE FIGURE vs. COLLECTOR CURRENT



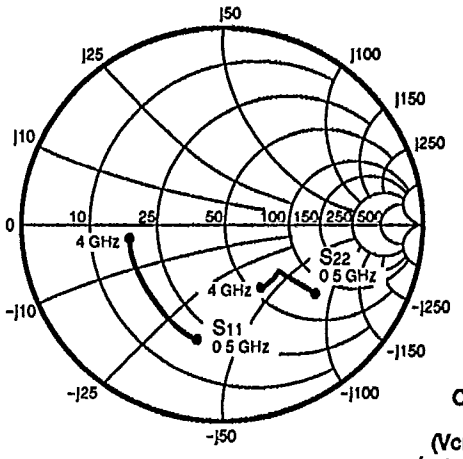
NE64508 OUTPUT POWER AT THE 1 dB COMPRESSION POINT vs. COLLECTOR CURRENT

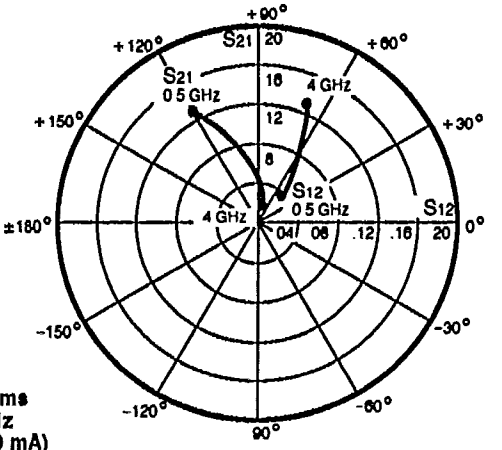


NE64587 OSCILLATOR OUTPUT POWER vs. FREQUENCY



TYPICAL COMMON EMITTER SCATTERING PARAMETERS





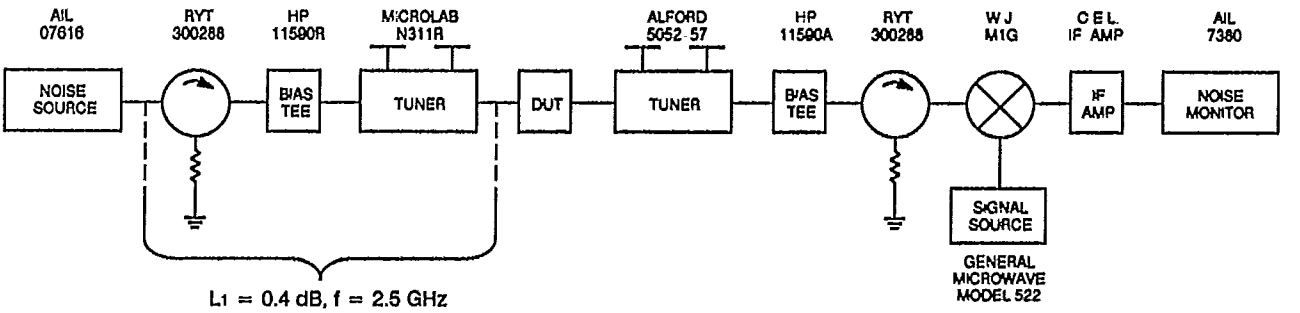
NE64500
Coordinates in Ohms
Frequency in GHz
(V_{CE} = 10 V, I_C = 10 mA)
(measured on alumina carrier)

S-MAGN AND ANGLES:

FREQUENCY (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
V_{CE} = 10 V, I_C = 5 mA								
500	.69	-75	10.60	129	.047	55	.72	-29
1000	.58	-112	6.30	108	.061	48	.56	-38
2000	.50	-140	3.44	89	.076	53	.47	-42
3000	.48	-156	2.31	71	.094	58	.47	-56
4000	.49	-166	1.79	62	.118	65	.46	-62
V_{CE} = 10 V, I_C = 10 mA								
500	.58	-99	13.88	119	.037	54	.59	-36
1000	.51	-130	7.54	101	.049	55	.45	-39
2000	.47	-152	3.97	86	.070	64	.39	-42
3000	.45	-164	2.61	71	.097	68	.40	-56
4000	.46	-172	2.04	62	.128	71	.39	-60
V_{CE} = 10 V, I_C = 20 mA								
500	.51	-121	15.81	111	.028	57	.48	-38
1000	.48	-144	8.14	97	.042	64	.38	-37
2000	.46	-160	4.21	84	.069	73	.35	-40
3000	.45	-169	2.74	70	.099	74	.36	-55
4000	.46	-175	2.14	61	.132	74	.36	-59

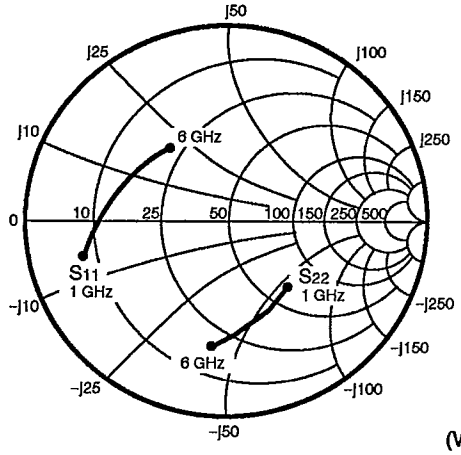
NOISE FIGURE TEST CIRCUIT

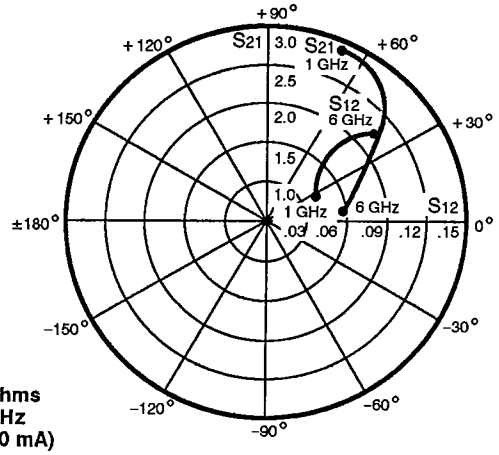
TEST CIRCUIT FOR f ≤ 4 GHz



L_1 = 0.4 dB, f = 2.5 GHz

TYPICAL COMMON EMITTER SCATTERING PARAMETERS





NE64508
Coordinates in Ohms
Frequency in GHz
(V_{CE} = 8 V, I_C = 10 mA)

S-MAGN AND ANGLES:

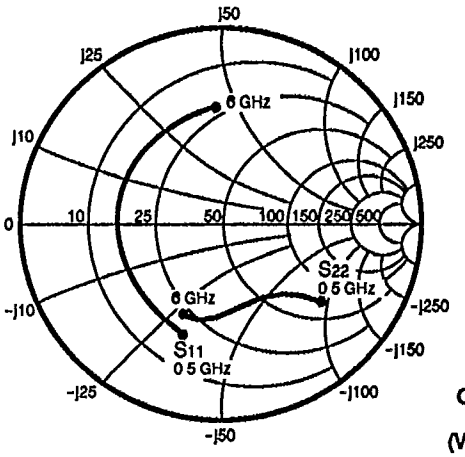
V_{CE} = 8 V, I_C = 7 mA

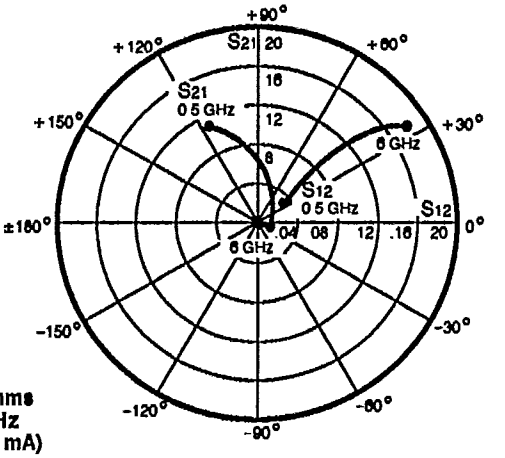
FREQUENCY (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
500	.82	-84	4.27	128	.042	38	.70	-62
1000	.77	-163	3.76	91	.050	38	.51	-58
2000	.63	-172	2.81	68	.055	33	.51	-60
2500	.60	-179	2.80	57	.069	44	.55	-67
3000	.59	175	2.44	48	.071	22	.56	-72
3500	.60	167	2.15	40	.069	25	.57	-78
4000	.56	160	1.85	30	.072	34	.60	-82
4500	.54	150	1.62	23	.067	31	.60	-85
5000	.51	148	1.49	19	.085	45	.65	-88
5500	.52	142	1.39	10	.103	38	.67	-94
6000	.50	131	1.27	4	.108	36	.68	-97

V_{CE} = 8 V, I_C = 10 mA

500	.78	-92	5.82	123	.035	37	.63	-65
1000	.72	-162	5.01	88	.045	24	.46	-58
2000	.63	-177	2.84	67	.052	41	.47	-61
2500	.62	178	2.85	57	.060	45	.49	-66
3000	.60	169	2.66	47	.070	44	.54	-70
3500	.59	162	2.35	39	.082	41	.54	-79
4000	.55	157	2.02	32	.077	45	.56	-83
4500	.51	147	1.75	24	.080	43	.57	-87
5000	.52	146	1.67	20	.080	51	.60	-87
5500	.51	139	1.53	11	.106	44	.63	-93
6000	.50	129	1.42	4	.118	40	.65	-97

TYPICAL COMMON EMITTER SCATTERING PARAMETERS



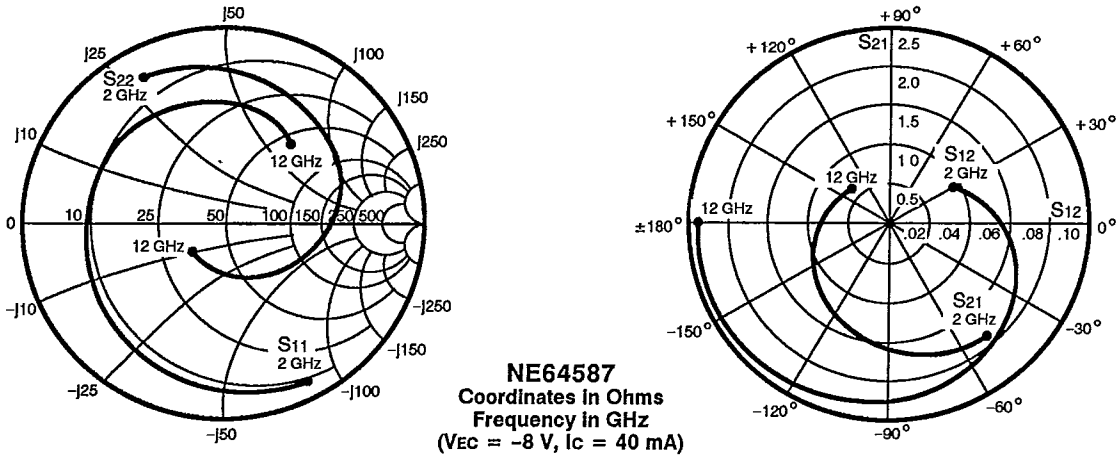


NE64535
Coordinates in Ohms
Frequency in GHz
(V_{CE} = 8 V, I_C = 7 mA)

S-MAGN AND ANGLES:

FREQUENCY (MHz)	S_{11}		S_{21}		S_{12}		S_{22}		k
V_{CE} = 8 V, I_C = 7 mA									
500	.61	-108	11.03	115	.03	37	.64	-37	0.53
1000	.54	-151	6.36	89	.05	39	.49	-44	0.87
2000	.53	173	3.45	64	.07	43	.44	-50	1.06
3000	.54	149	2.36	42	.10	44	.43	-64	1.16
4000	.56	131	1.79	24	.12	43	.44	-80	1.13
5000	.60	115	1.44	7	.15	39	.46	-98	1.02
6000	.63	95	1.26	-10	.18	33	.48	-113	0.89
V_{CE} = 8 V, I_C = 10 mA									
500	.56	-122	12.34	110	.03	41	.58	-39	0.67
1000	.52	-161	6.83	87	.04	42	.44	-42	1.11
2000	.52	168	3.69	63	.07	48	.40	-49	1.13
3000	.53	146	2.49	42	.10	47	.40	-63	1.16
4000	.56	129	1.89	23	.12	44	.41	-81	1.12
5000	.59	114	1.53	7	.15	39	.44	-98	1.03
6000	.63	94	1.34	-10	.18	32	.46	-112	0.88
V_{CE} = 8 V, I_C = 20 mA									
500	.53	-145	13.79	101	.02	40	.48	-38	0.97
1000	.52	-176	7.26	82	.03	54	.39	-38	1.42
2000	.52	162	3.79	60	.06	62	.39	-46	1.23
3000	.53	125	2.58	23	.10	38	.38	-77	1.12
4000	.56	102	1.96	-0	.13	26	.39	-102	1.07
5000	.60	81	1.62	-23	.16	13	.41	-125	0.94
6000	.64	56	1.37	-47	.19	0	.42	-148	0.86
V_{CE} = 8 V, I_C = 30 mA									
500	.52	-156	13.77	97	.02	44	.45	-33	1.19
1000	.53	179	7.13	80	.03	60	.38	-34	1.64
2000	.53	158	3.68	59	.06	63	.40	-44	1.24
3000	.54	140	2.52	39	.10	57	.40	-61	1.15
4000	.55	124	1.89	21	.13	51	.42	-79	1.09
5000	.59	109	1.55	4	.16	44	.43	-96	0.98
6000	.65	89	1.33	-14	.19	37	.44	-113	0.84

TYPICAL COMMON COLLECTOR SCATTERING PARAMETERS



NE64587
Coordinates in Ohms
Frequency in GHz
(VEC = −8 V, IC = 40 mA)

S-MAGN AND ANGLES:

VEC = −8 V, IC = 10 mA

FREQUENCY (MHz)	S11		S21		S12		S22	
2000	.92	−59	1.70	−44	.37	40	.79	120
3000	.87	−85	1.58	−64	.50	18	.70	90
4000	.81	−115	1.50	−79	.60	2	.71	78
5000	.72	−135	1.35	−100	.69	−19	.68	43
6000	.66	−163	1.23	−115	.76	−39	.65	22
7000	.60	172	1.09	−135	.84	−63	.61	−1
8000	.60	148	1.02	−152	.90	−79	.55	−18
9000	.58	114	.93	−167	.90	−101	.46	−43
10000	.58	92	.87	180	.94	−119	.39	−59
11000	.56	60	.80	155	.94	−146	.32	−82
12000	.58	40	.73	137	.87	−167	.19	−94

VEC = −8 V, IC = 20 mA

2000	.92	−60	1.74	−44	.36	41	.85	125
3000	.91	−84	1.65	−64	.49	19	.76	93
4000	.82	−113	1.55	−79	.60	2	.77	80
5000	.74	−133	1.41	−101	.70	−21	.72	42
6000	.67	−160	1.30	−116	.77	−41	.69	20
7000	.60	175	1.14	−136	.81	−66	.64	−4
8000	.58	151	1.08	−153	.86	−82	.59	−20
9000	.57	117	1.00	−169	.85	−103	.51	−43
10000	.56	92	.92	177	.89	−119	.47	−56
11000	.55	.58	.83	152	.88	−145	.42	−74
12000	.58	35	.75	135	.84	−168	.33	−82

VEC = −8 V, IC = 40 mA

2000	.89	−61	1.82	−47	.38	33	.85	118
3000	.83	−91	1.75	−70	.52	11	.81	90
4000	.75	−120	1.52	−90	.62	−9	.77	66
5000	.69	−150	1.36	−112	.71	−32	.71	42
6000	.66	−180	1.21	−132	.79	−52	.64	22
7000	.66	155	1.09	−148	.84	−74	.56	2
8000	.67	129	.98	−168	.88	−93	.47	−15
9000	.63	104	.84	179	.90	−116	.38	−38
10000	.61	84	.76	159	.96	−137	.31	−63
11000	.59	63	.68	144	.95	−166	.23	−95
12000	.54	49	.67	132	.95	177	.20	−140