



# PNP SILICON HIGH FREQUENCY TRANSISTOR

T-31-17  
**NE88900**  
**NE88912**  
**NE88933**  
**NE88935**

## FEATURES

- PNP COMPLEMENT TO NE327
- HIGH GAIN BANDWIDTH PRODUCT:  $f_r = 4$  GHz
- HIGH GAIN: 18 dB at 500 MHz
- LOW NOISE: 2 dB at 500 MHz
- RELIABLE: Gold Metallization and Rugged Packages

## DESCRIPTION AND APPLICATIONS

The NE889 series of PNP silicon transistors is designed for ultra high speed current mode switching applications and microwave amplifiers up to 2 GHz. The NE889 is available in several package styles and in chip form (NE88900). The NE88935 is an economical metal ceramic stripline version which features low parasitic elements and is ideal for low cost hybrid circuits. Reliability is assured by NEC's stringent production controls, which are patterned after MIL-S-19500 and Pt/Si-Ti-Pt-Au metallization.

## PERFORMANCE SPECIFICATIONS (T<sub>A</sub> = 25°C)

| PART NUMBER<br>EIAJ <sup>1</sup> REGISTERED NUMBER<br>PACKAGE OUTLINE |  |                | NE88900<br>00 (CHIP) |     |     | NE88912<br>2SA1228<br>12 (TO-72) |                |     | NE88933<br>2SA1424<br>33 (MINI-MOLD) |     |     | NE88935<br>2SA1223<br>35 (MICRO-X) |                 |          |
|---|--|----------------|----------------------|-----|-----|----------------------------------|----------------|-----|--------------------------------------|-----|-----|------------------------------------|-----------------|----------|
| SYMBOLS   | PARAMETERS AND CONDITIONS  | UNITS          | MIN                  | TYP | MAX | MIN                              | TYP            | MAX | MIN                                  | TYP | MAX | MIN                                | TYP             | MAX      |
| $f_r$   | Gain Bandwidth Product at<br>V <sub>CE</sub> = -5 V, I <sub>c</sub> = -15 mA   | GHz            |                      | 4   |     |                                  | 4              |     | 3                                    | 4   |     | 3                                  | 4               |          |
| S <sub>21E</sub>   <sup>2</sup>                                       | Insertion Power Gain at<br>V <sub>CE</sub> = -10 V, I <sub>c</sub> = -15 mA,<br>f = 0.5 GHz<br>f = 1 GHz<br>f = 2 GHz                | dB<br>dB<br>dB |                      |     |     |                                  | 13<br>7.2<br>2 |     | 6                                    | 8   |     | 8                                  | 16<br>10<br>4.2 |          |
| NF <sub>MIN</sub>   | Minimum Noise Figure <sup>2</sup> at<br>V <sub>CE</sub> = -10 V, I <sub>c</sub> = -3 mA,<br>f = 0.2 GHz<br>f = 0.5 GHz<br>f = 1 GHz  | dB<br>dB<br>dB |                      | 2.5 |     |                                  | 2<br>2.5<br>3  |     |                                      | 3   | 4   |                                    | 1.8<br>2<br>2.5 | 3.5<br>4 |
| MAG   | Maximum Available Gain <sup>3</sup> at<br>V <sub>CE</sub> = -10 V, I <sub>c</sub> = -15 mA,<br>f = 0.5 GHz<br>f = 1 GHz<br>f = 2 GHz | dB<br>dB<br>dB |                      | 12  |     |                                  | 14.5<br>9<br>3 |     |                                      | 9.3 |     |                                    | 18<br>12<br>7   |          |

**Notes:**

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

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

**NE88900, NE88912, NE88933, NE88935**

**ELECTRICAL CHARACTERISTICS** ( $T_A = 25^\circ\text{C}$ )

| PART NUMBER<br>EIAJ <sup>1</sup> REGISTERED NUMBER<br>PACKAGE OUTLINE |  |                    | NE88900<br>00 (CHIP) |     |      | NE88912<br>2SA1228<br>12 (TO-72) |     |      | NE88933<br>2SA1424<br>33 (MINI-MOLD) |     |      | NE88935<br>2SA1223<br>35 (MICRO-X) |     |      |
|---|--|--------------------|----------------------|-----|------|----------------------------------|-----|------|--------------------------------------|-----|------|------------------------------------|-----|------|
| SYMBOLS   | PARAMETERS AND CONDITIONS  | UNITS              | MIN                  | TYP | MAX  | MIN                              | TYP | MAX  | MIN                                  | TYP | MAX  | MIN                                | TYP | MAX  |
| Icbo  | Collector Cutoff Current at<br>$V_{CB} = -10\text{ V}, I_E = 0$  | $\mu\text{A}$      |                      |     | -0.1 |                                  |     | -0.1 |                                      |     | -0.1 |                                    |     | -0.1 |
| Iebo  | Emitter Cutoff Current at<br>$V_{EB} = -2\text{ V}, I_C = 0$   | $\mu\text{A}$      |                      |     | -0.1 |                                  |     | -0.1 |                                      |     | -0.1 |                                    |     | -0.1 |
| hFE   | Forward Current Gain at<br>$V_{CE} = -10\text{ V}, I_C = -15\text{ mA}$                                      |                    | 20                   | 90  | 200  | 20                               | 90  | 200  | 20                                   | 90  | 200  | 20                                 | 90  | 200  |
| Ccb   | Collector to Base Capacitance <sup>2</sup> at<br>$V_{CB} = -5\text{ V}, I_E = 0\text{ mA}, f = 1\text{ MHz}$ | pF                 |                      | 1.2 | 1.5  |                                  | 1.2 | 1.5  |                                      | 1.1 | 3    |                                    | 1   | 1.5  |
| Rth   | Thermal Resistance (Junction-to-Case)  | $^\circ\text{C/W}$ |                      |     | 31   |                                  |     | 500  |                                      |     | 700  |                                    |     | 620  |
| Pr  | Total Power Dissipation  | mW                 |                      |     |      |                                  |     | 300  |                                      |     | 200  |                                    |     | 250  |

**Notes:**

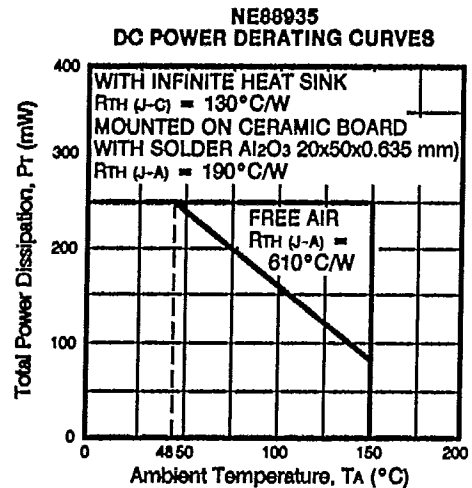
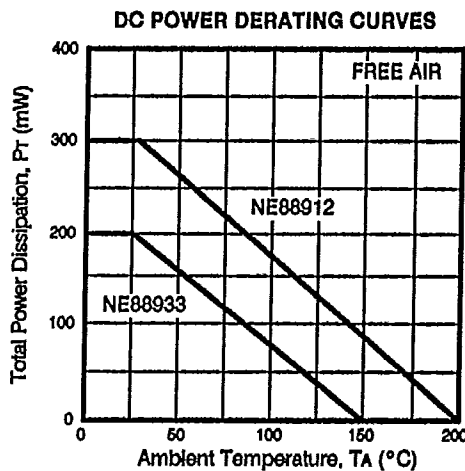
1. Electronic Industrial Association of Japan.
2. Capacitance is measured with emitter and case connected to the guard terminal at the bridge.

**ABSOLUTE MAXIMUM RATINGS** ( $T_A = 25^\circ\text{C}$ )

| SYMBOLS | PARAMETERS                   | UNITS            | RATINGS      |
|---------|------------------------------|------------------|--------------|
| Vcbo    | Collector to Base Voltage    | V                | -20          |
| Vceo    | Collector to Emitter Voltage | V                | -12          |
| Vebo    | Emitter to Base Voltage      | V                | -3           |
| Ic      | Collector Current            | mA               | -50          |
| Tj      | Junction Temperature         | $^\circ\text{C}$ | 200          |
| Tsrg    | Storage Temperature          | $^\circ\text{C}$ | -65 to +200* |

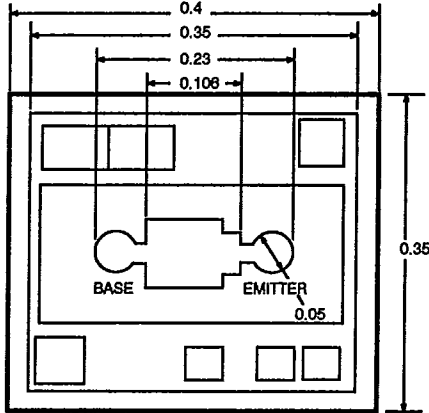
\*The NE88935 Grade D (Industrial) version has a Tsrg of -65 to +150 $^\circ\text{C}$ .

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

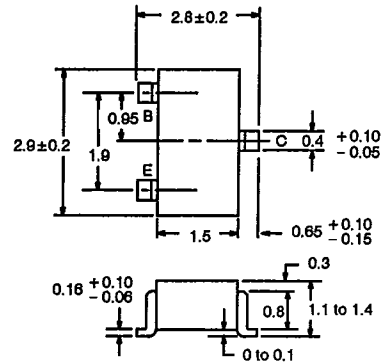


**OUTLINE DIMENSIONS** (Units in mm)

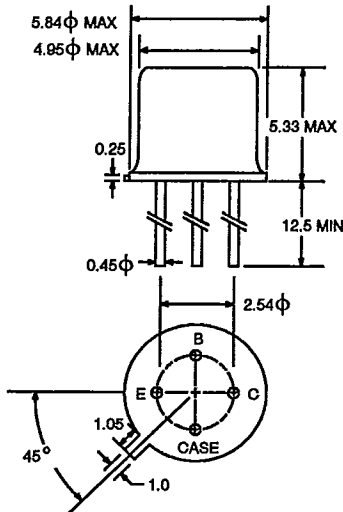
**NE88900 (CHIP)**  
 Chip Thickness: 160 μm TYP



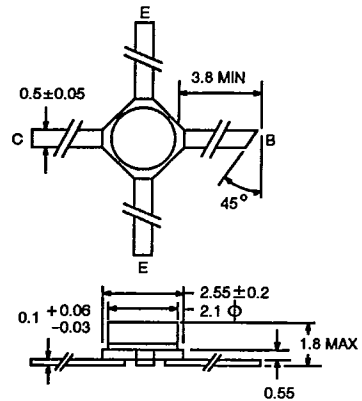
**OUTLINE 33**  
 (SOT-23)



**OUTLINE 12**  
 (TO-72)

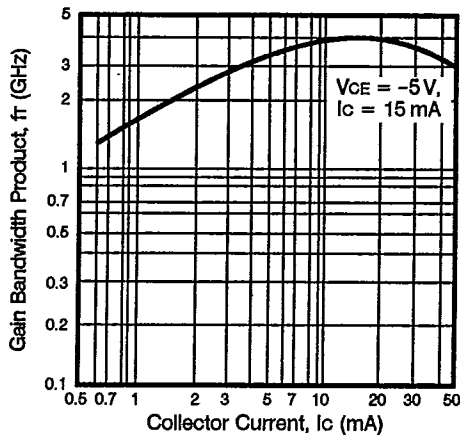


**OUTLINE 35**  
 (MICRO-X)

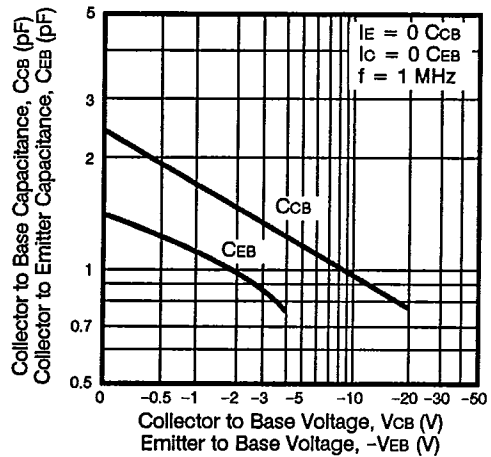


**TYPICAL PERFORMANCE CHARACTERISTICS** (T<sub>A</sub> = 25°C)

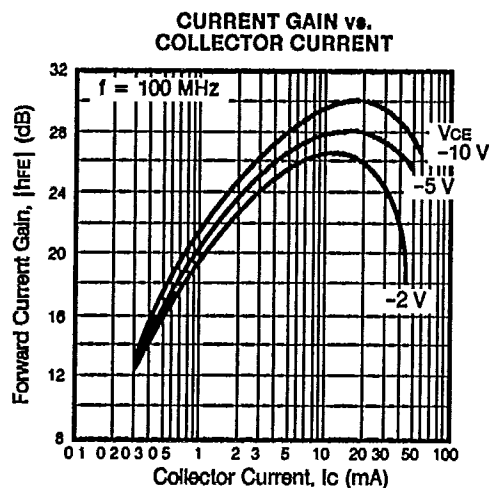
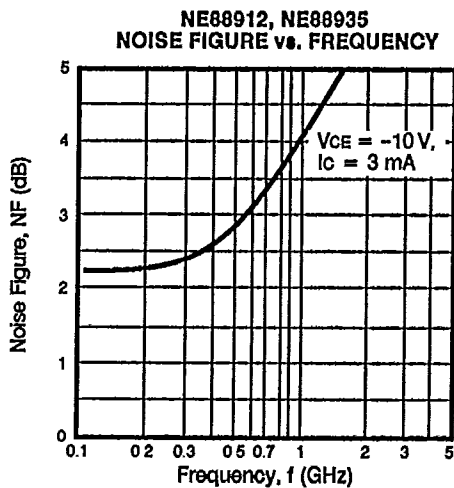
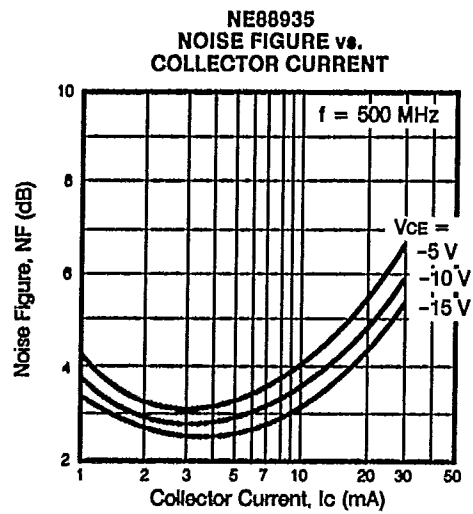
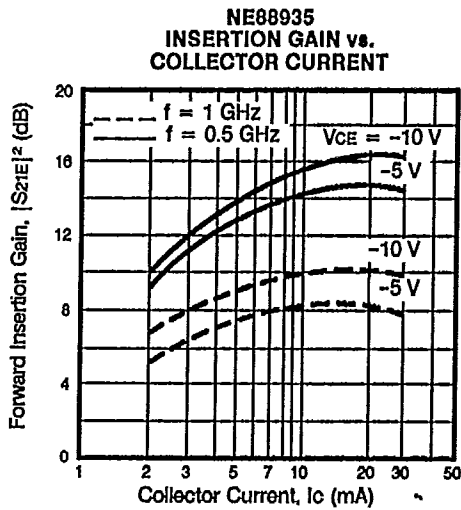
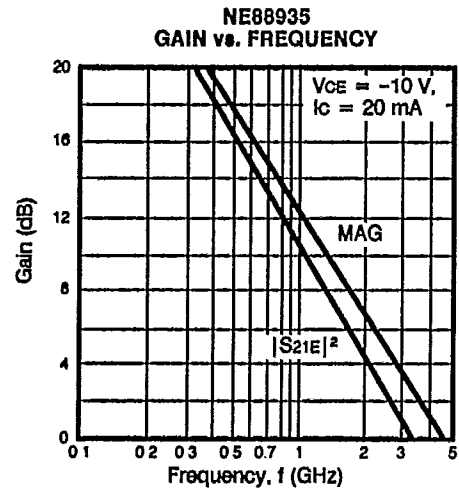
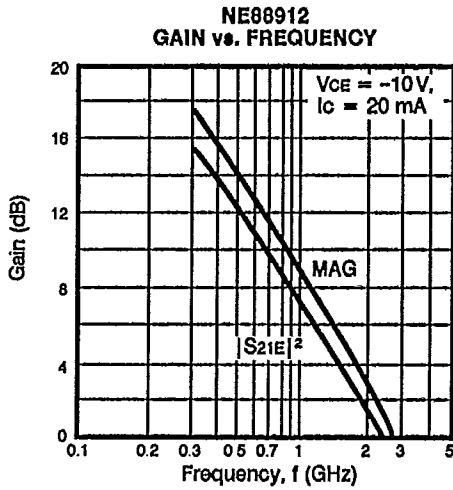
**GAIN BANDWIDTH vs. COLLECTOR CURRENT**



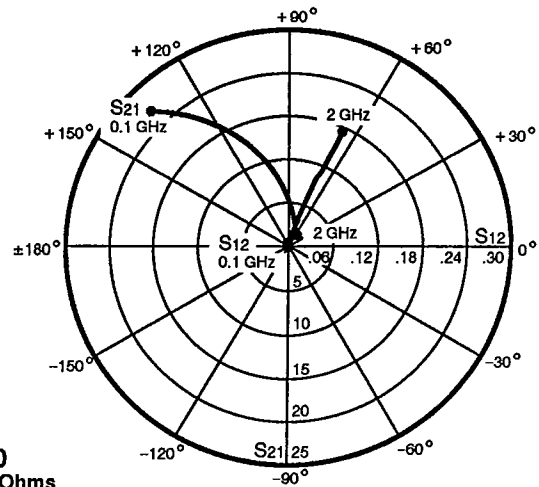
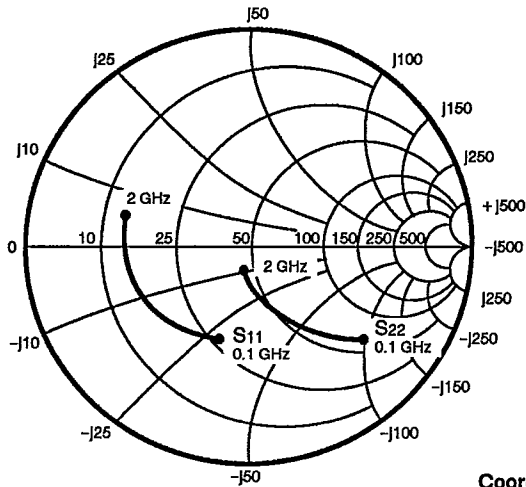
**DEVICE CAPACITANCE**



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



**TYPICAL COMMON EMITTER SCATTERING PARAMETERS**



**NE88900**  
Coordinates in Ohms  
Frequency in GHz  
(VCE = -10 V, IC = -30 mA)

**S-MAGN AND ANGLES:**

VCE = -10 V, IC = -5 mA

FREQUENCY (MHz)

S11

S21

S12

S22

|      |     |      |       |     |      |    |     |     |
|------|-----|------|-------|-----|------|----|-----|-----|
| 100  | .75 | -39  | 11.69 | 154 | .021 | 78 | .90 | -21 |
| 500  | .55 | -128 | 5.34  | 103 | .097 | 44 | .40 | -64 |
| 1000 | .49 | -155 | 2.89  | 84  | .128 | 47 | .27 | -74 |
| 1500 | .49 | -173 | 2.03  | 72  | .160 | 48 | .20 | -80 |
| 2000 | .53 | 176  | 1.60  | 63  | .195 | 51 | .19 | -89 |

VCE = -10 V, IC = -10 mA

|      |     |      |       |     |      |    |     |      |
|------|-----|------|-------|-----|------|----|-----|------|
| 100  | .60 | -60  | 17.27 | 146 | .016 | 71 | .82 | -30  |
| 500  | .53 | -149 | 6.10  | 98  | .066 | 50 | .28 | -78  |
| 1000 | .50 | -168 | 3.21  | 82  | .107 | 57 | .19 | -91  |
| 1500 | .51 | 178  | 2.24  | 71  | .146 | 58 | .14 | -99  |
| 2000 | .55 | 170  | 1.74  | 63  | .186 | 59 | .13 | -108 |

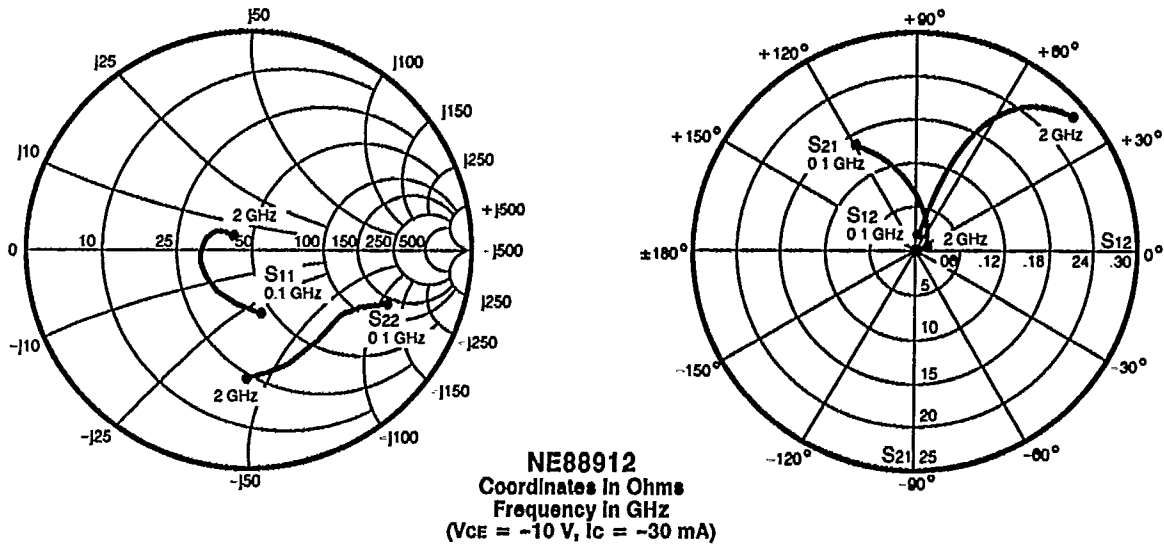
VCE = -10 V, IC = -20 mA

|      |     |      |       |     |      |    |     |      |
|------|-----|------|-------|-----|------|----|-----|------|
| 100  | .48 | -88  | 21.54 | 138 | .007 | 70 | .72 | -38  |
| 500  | .54 | -162 | 6.39  | 94  | .045 | 58 | .21 | -87  |
| 1000 | .51 | -175 | 3.31  | 80  | .093 | 64 | .15 | -99  |
| 1500 | .53 | 173  | 2.29  | 70  | .139 | 63 | .10 | -105 |
| 2000 | .57 | 166  | 1.77  | 62  | .182 | 65 | .11 | -115 |

VCE = -10 V, IC = -30 mA

|      |     |      |       |     |      |    |     |      |
|------|-----|------|-------|-----|------|----|-----|------|
| 100  | .44 | -105 | 22.51 | 135 | .004 | 78 | .68 | -39  |
| 500  | .55 | -166 | 6.25  | 92  | .044 | 61 | .18 | -84  |
| 1000 | .53 | -178 | 3.22  | 79  | .090 | 68 | .14 | -92  |
| 1500 | .54 | 172  | 2.22  | 69  | .134 | 66 | .09 | -94  |
| 2000 | .59 | 165  | 1.71  | 61  | .177 | 66 | .11 | -106 |

**TYPICAL COMMON EMITTER SCATTERING PARAMETERS**



**S-MAGN AND ANGLES:**

VCE = -10 V, IC = -5 mA

FREQUENCY (MHz)

|      | S11 |      | S21   |     | S12  |    | S22 |     |
|------|-----|------|-------|-----|------|----|-----|-----|
| 100  | .65 | -40  | 10.20 | 141 | .035 | 70 | .85 | -20 |
| 500  | .30 | -114 | 3.95  | 88  | .112 | 59 | .55 | -41 |
| 1000 | .20 | -154 | 2.23  | 62  | .178 | 56 | .49 | -54 |
| 1500 | .16 | -173 | 1.62  | 41  | .237 | 49 | .51 | -72 |
| 2000 | .12 | -164 | 1.30  | 21  | .281 | 37 | .57 | -89 |

VCE = -10 V, IC = -10 mA

|      |     |      |       |     |      |    |     |     |
|------|-----|------|-------|-----|------|----|-----|-----|
| 100  | .49 | -51  | 13.51 | 132 | .031 | 73 | .78 | -23 |
| 500  | .22 | -128 | 4.25  | 83  | .106 | 64 | .49 | -38 |
| 1000 | .17 | -166 | 2.34  | 60  | .182 | 59 | .46 | -51 |
| 1500 | .14 | 179  | 1.70  | 40  | .244 | 50 | .49 | -69 |
| 2000 | .09 | -167 | 1.36  | 21  | .290 | 38 | .54 | -87 |

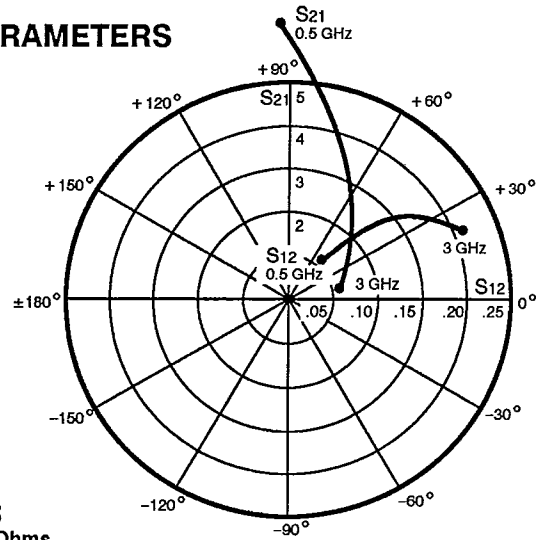
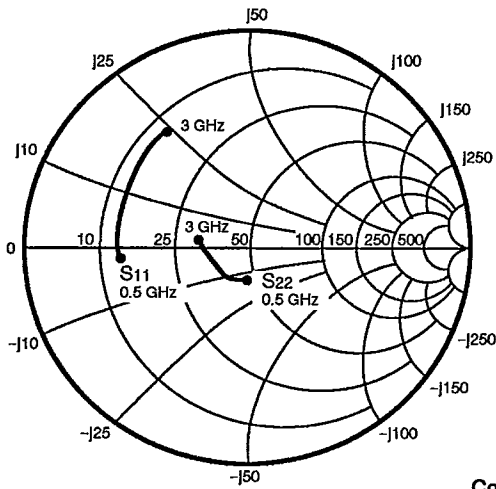
VCE = -10 V, IC = -20 mA

|      |     |      |       |     |      |    |     |     |
|------|-----|------|-------|-----|------|----|-----|-----|
| 100  | .36 | -65  | 14.73 | 123 | .027 | 72 | .70 | -24 |
| 500  | .19 | -145 | 4.11  | 79  | .103 | 67 | .49 | -34 |
| 1000 | .17 | -179 | 2.25  | 57  | .179 | 61 | .47 | -49 |
| 1500 | .14 | 166  | 1.63  | 37  | .246 | 52 | .50 | -68 |
| 2000 | .08 | -179 | 1.29  | 17  | .287 | 39 | .57 | -87 |

VCE = -10 V, IC = -30 mA

|      |     |      |       |     |      |    |     |     |
|------|-----|------|-------|-----|------|----|-----|-----|
| 100  | .30 | -80  | 13.70 | 119 | .021 | 70 | .68 | -22 |
| 500  | .22 | -159 | 3.62  | 77  | .099 | 69 | .51 | -31 |
| 1000 | .21 | 168  | 1.99  | 54  | .174 | 63 | .51 | -49 |
| 1500 | .18 | 150  | 1.44  | 34  | .238 | 54 | .54 | -68 |
| 2000 | .10 | 140  | 1.15  | 14  | .282 | 42 | .59 | -89 |

**TYPICAL COMMON EMITTER SCATTERING PARAMETERS**



**NE88935**  
Coordinates in Ohms  
Frequency in GHz  
(VCE = -10 V, IC = -20 mA, Zo = 50 Ω)

**S-MAGN AND ANGLES:**

VCE = -10 V, IC = -5 mA

FREQUENCY (MHz)

|      | S11 |      | S21  |     | S12 |    | S22 |      |
|------|-----|------|------|-----|-----|----|-----|------|
| 500  | .46 | -133 | 5.08 | 104 | .11 | 40 | .30 | -56  |
| 1000 | .54 | -170 | 2.82 | 72  | .14 | 29 | .25 | -96  |
| 2000 | .56 | 153  | 1.51 | 38  | .19 | 22 | .19 | -133 |
| 3000 | .59 | 130  | 1.05 | 12  | .24 | 10 | .23 | -168 |

VCE = -10 V, IC = -10 mA

|      |     |      |      |    |     |    |     |      |
|------|-----|------|------|----|-----|----|-----|------|
| 500  | .50 | -160 | 6.11 | 97 | .08 | 43 | .18 | -76  |
| 1000 | .57 | 177  | 3.12 | 70 | .11 | 38 | .19 | -117 |
| 2000 | .59 | 147  | 1.63 | 38 | .17 | 31 | .16 | -156 |
| 3000 | .62 | 126  | 1.12 | 14 | .22 | 18 | .22 | 175  |

VCE = -10 V, IC = -20 mA

|      |     |      |      |    |     |    |     |      |
|------|-----|------|------|----|-----|----|-----|------|
| 500  | .56 | -176 | 6.53 | 93 | .06 | 50 | .10 | -95  |
| 1000 | .59 | 170  | 3.19 | 68 | .09 | 47 | .15 | -128 |
| 2000 | .62 | 144  | 1.65 | 38 | .16 | 38 | .15 | -163 |
| 3000 | .65 | 125  | 1.12 | 13 | .21 | 24 | .21 | 172  |

VCE = -10 V, IC = -30 mA

|      |     |     |      |    |     |    |     |      |
|------|-----|-----|------|----|-----|----|-----|------|
| 500  | .59 | 178 | 6.44 | 91 | .06 | 54 | .07 | -94  |
| 1000 | .60 | 168 | 3.10 | 67 | .09 | 51 | .14 | -122 |
| 2000 | .63 | 143 | 1.59 | 37 | .16 | 40 | .14 | -157 |
| 3000 | .66 | 124 | 1.07 | 12 | .21 | 26 | .21 | 178  |