

**NEC**<sup>®</sup>**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<sub>A</sub> = 25°C)

| SYMBOLS          | PARAMETERS                   | UNITS | RATINGS      |
|------------------|------------------------------|-------|--------------|
| V <sub>CB0</sub> | Collector to Base Voltage    | V     | 35           |
| V <sub>CE0</sub> | Collector to Emitter Voltage | V     | 18           |
| V <sub>EB0</sub> | Emitter to Base Voltage      | V     | 3            |
| I <sub>C</sub>   | Collector Current            | mA    | 100          |
| T <sub>J</sub>   | Junction Temperature         | °C    | 200*         |
| T <sub>STG</sub> | Storage Temperature          | °C    | -65 to +200* |

\* Maximum Storage Temperature (T<sub>STG</sub>) 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**V<sub>CE</sub> = 10 V, I<sub>C</sub> = 5 mA

| FREQUENCY (MHz) | NF min (dB) | G <sub>A</sub> /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<sub>CE</sub> = 10 V, I<sub>C</sub> = 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<sub>A</sub> = 25°C)

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

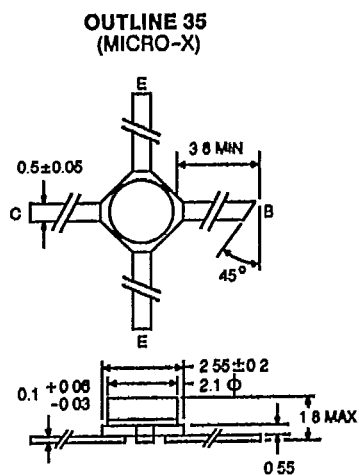
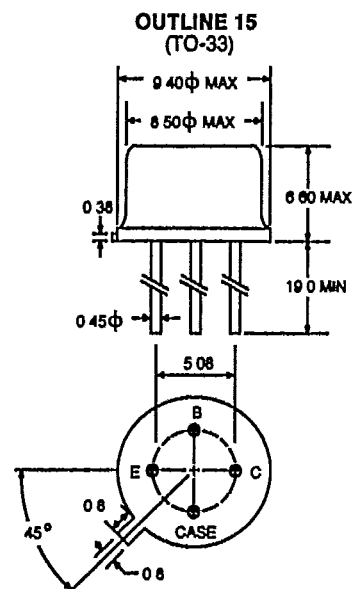
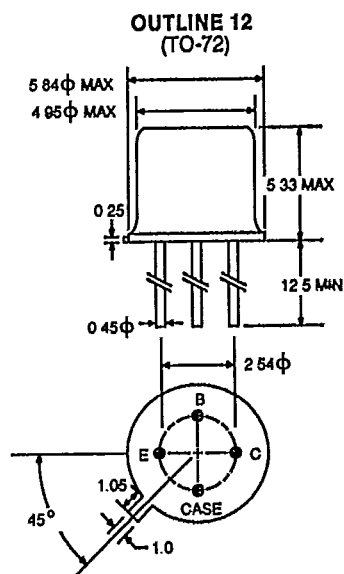
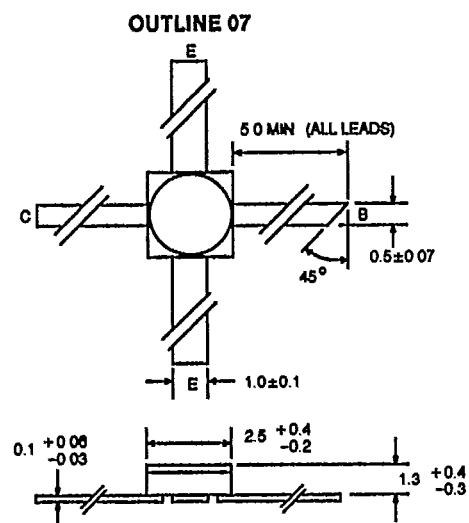
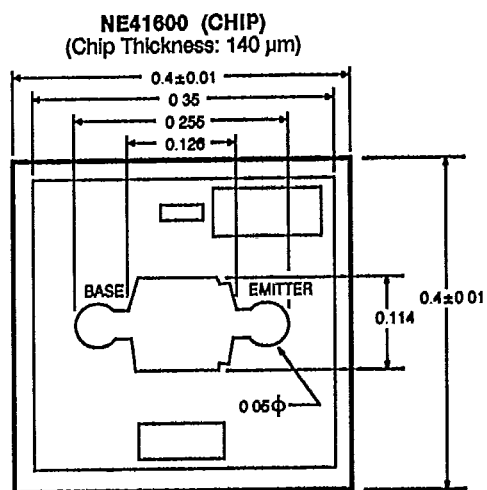
ELECTRICAL CHARACTERISTICS (T<sub>A</sub> = 25°C)

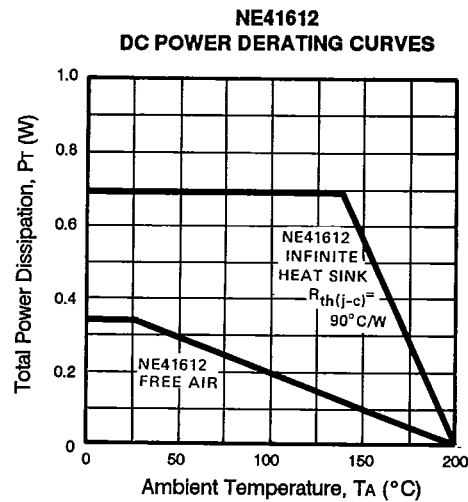
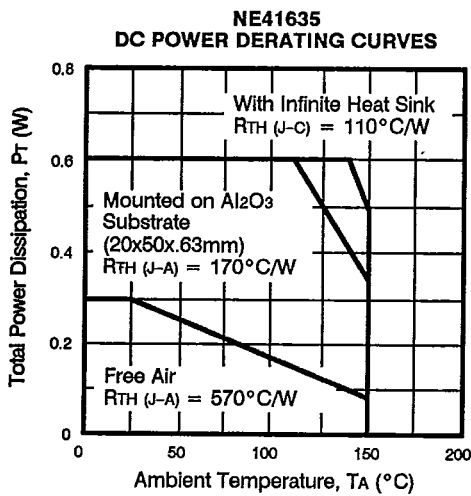
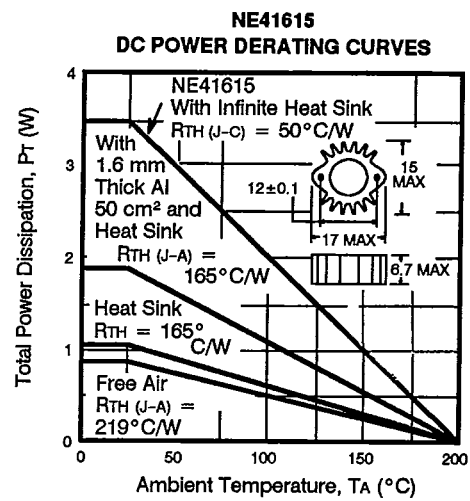
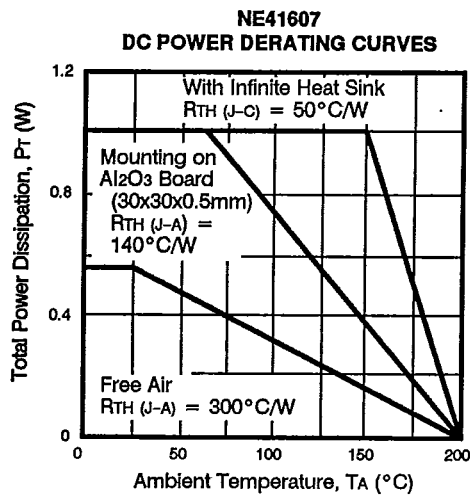
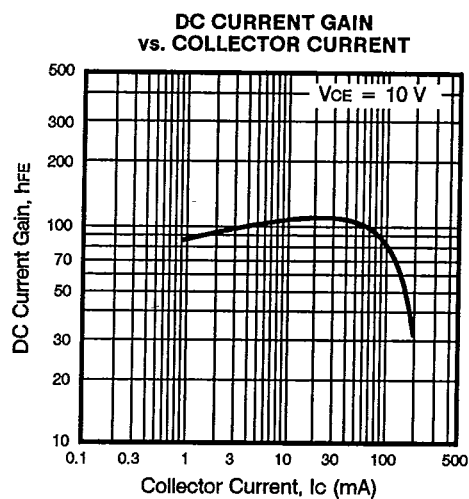
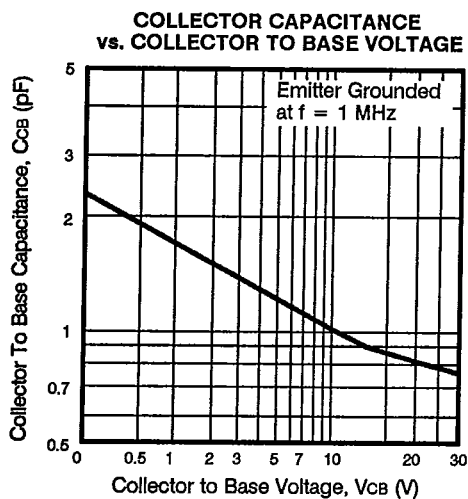
| PART NUMBER<br>EIAJ <sup>2</sup> REGISTERED NUMBER<br><br>PACKAGE CODE |                                                                                                                                                                                                                                                |                      | NE41607<br><br>07 |                   |     | NE41612<br>NE416121 <sup>3</sup><br>2SC2025 (GrdD)<br>NC921 (Grd D)<br>12 (TO-72) |                 |     | NE41615<br>2SC1426 (GrdCX)<br><br>15 (TO-33) |                   |     | NE41635<br><br>35 (MICRO-X) |            |     |
|------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|-------------------|-------------------|-----|-----------------------------------------------------------------------------------|-----------------|-----|----------------------------------------------|-------------------|-----|-----------------------------|------------|-----|
| SYMBOLS                                                                | PARAMETERS & CONDITIONS                                                                                                                                                                                                                        | UNITS                | MIN               | TYP               | MAX | MIN                                                                               | TYP             | MAX | MIN                                          | TYP               | MAX | MIN                         | TYP        | MAX |
| f <sub>T</sub>                                                         | Gain Bandwidth Product at<br>V <sub>CE</sub> = 5 V, I <sub>C</sub> = 25 mA<br>V <sub>CE</sub> = 10 V, I <sub>C</sub> = 50 mA                                                                                                                   | GHz<br>GHz           | 2                 | 3.5               |     | 1.5                                                                               | 2.7             |     | 2                                            | 3.5               |     | 2                           | 3.5        |     |
| S <sub>21E</sub>   <sup>2</sup>                                        | Insertion Power Gain at<br>V <sub>CE</sub> = 10 V, I <sub>C</sub> = 30 mA<br>f = 0.5 GHz<br>f = 1.0 GHz                                                                                                                                        | dB<br>dB             | 7                 | 16<br>9.5         |     |                                                                                   | 13<br>8         |     |                                              | 13<br>8           |     | 7                           | 16<br>9.5  |     |
| NF <sub>MIN</sub>                                                      | Minimum Noise Figure at<br>V <sub>CE</sub> = 10 V, I <sub>C</sub> = 5 mA, R <sub>G</sub> = 50 Ω<br>f = 0.2 GHz<br>f = 0.5 GHz<br>f = 1.0 GHz<br>V <sub>CE</sub> = 5 V, I <sub>C</sub> = 2 mA, R <sub>G</sub> = 200 Ω<br>f = 70 MHz (NE41612-1) | dB<br>dB<br>dB<br>dB |                   | 1.2<br>1.5<br>3.5 |     |                                                                                   | 2.3<br>2.8<br>5 | 4   |                                              | 1.4<br>1.5<br>3.7 |     |                             | 1.5<br>3.5 |     |
| MAG                                                                    | Maximum Available Gain <sup>6</sup> at<br>V <sub>CE</sub> = 10 V, I <sub>C</sub> = 30 mA<br>f = 0.5 GHz<br>f = 1.0 GHz                                                                                                                         | dB<br>dB             |                   | 20<br>14          |     |                                                                                   | 15.5<br>10      |     |                                              | 15.5<br>10        |     |                             | 21<br>14   |     |

## Notes:

- Maximum Storage Temperature (T<sub>STG</sub>) 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<sub>CB</sub> measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter terminal shall be connected to the guard terminal.

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

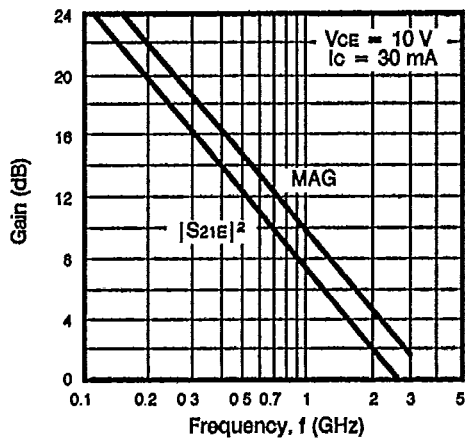
**NE416 SERIES****OUTLINE DIMENSIONS** (Units in mm)

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

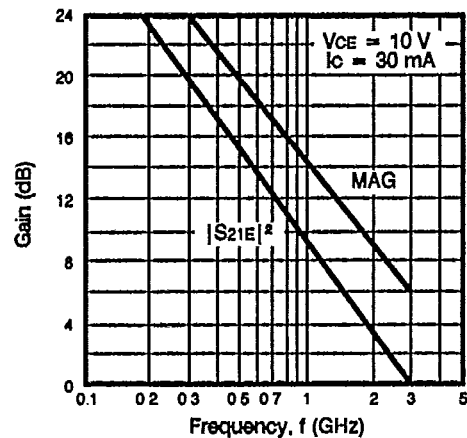
## NE416 SERIES

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

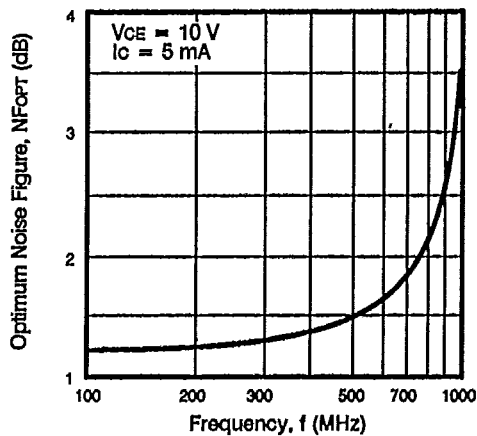
NE41612 AND NE41615  
FORWARD INSERTION GAIN  
AND MAXIMUM AVAILABLE GAIN  
vs. FREQUENCY



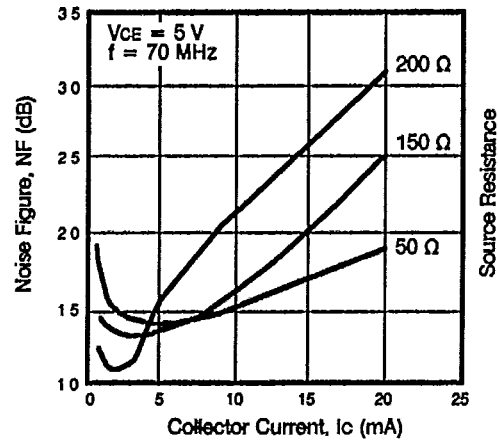
NE41607  
FORWARD INSERTION GAIN AND  
MAXIMUM AVAILABLE GAIN  
vs. FREQUENCY



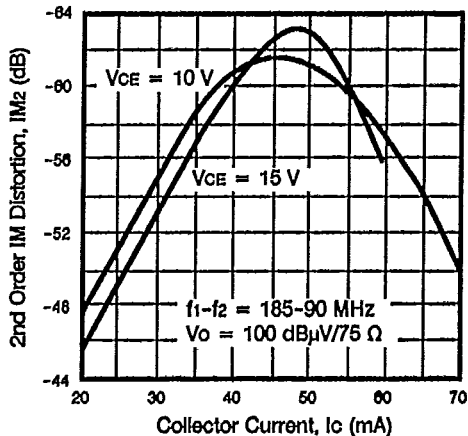
NE41607  
NOISE FIGURE vs. FREQUENCY



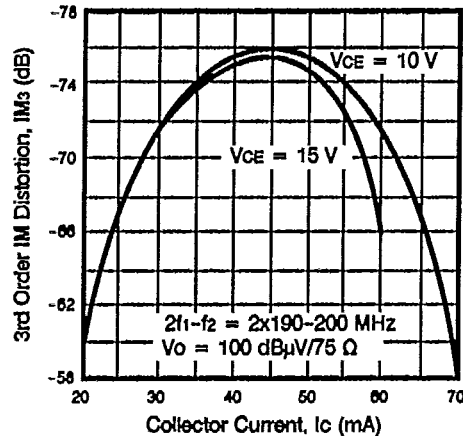
NE41612-1  
NOISE FIGURE vs.  
COLLECTOR CURRENT AND  
SOURCE RESISTANCE



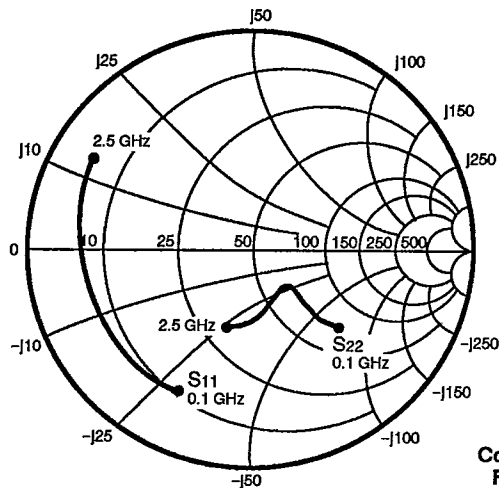
NE41615  
SECOND ORDER IM DISTORTION  
vs. COLLECTOR CURRENT



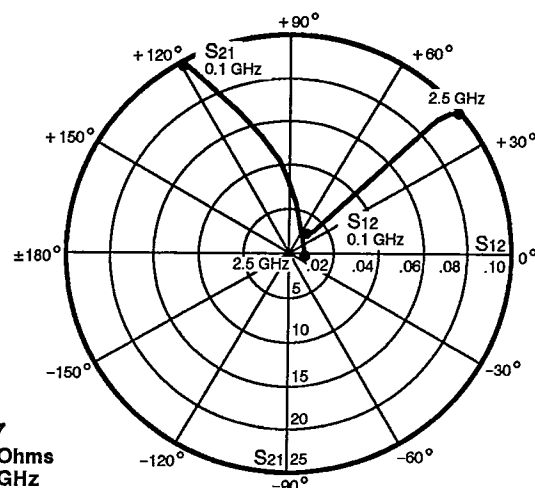
NE41615  
THIRD ORDER IM DISTORTION  
vs. COLLECTOR CURRENT



## 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 <sub>11</sub> |      | S <sub>21</sub> |     | S <sub>12</sub> |    | S <sub>22</sub> |      |
|------|-----------------|------|-----------------|-----|-----------------|----|-----------------|------|
| 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 |

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

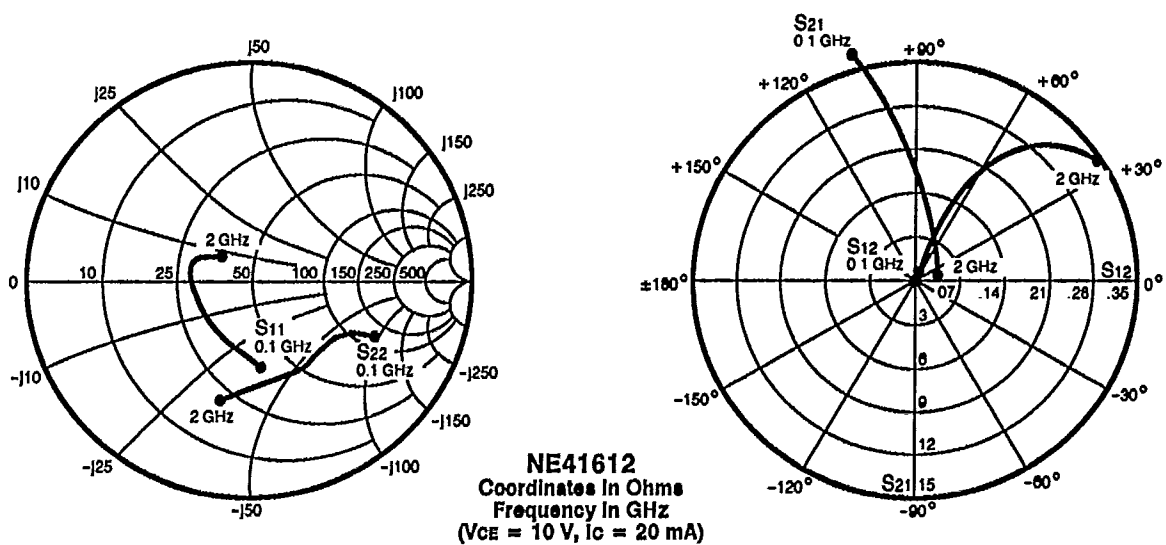
|      |     |      |       |     |     |    |     |      |
|------|-----|------|-------|-----|-----|----|-----|------|
| 100  | .73 | -130 | 26.90 | 114 | .01 | 47 | .50 | -49  |
| 500  | .76 | -175 | 6.05  | 80  | .03 | 45 | .17 | -53  |
| 1000 | .77 | 175  | 3.02  | 62  | .05 | 48 | .18 | -64  |
| 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 |

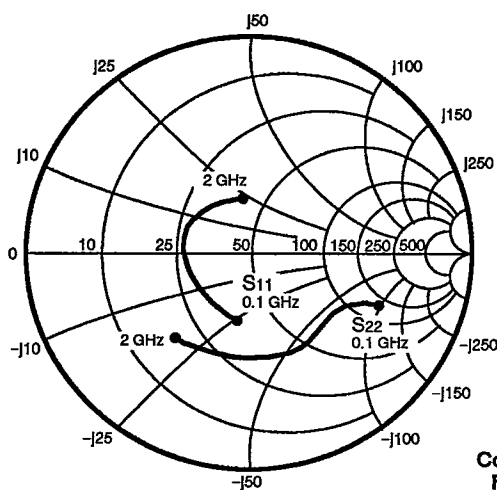
VCE = 10 V, IC = 20 mA

|      | 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 |

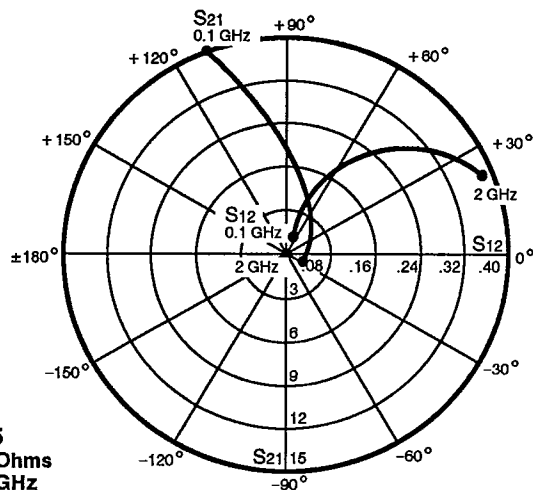
VCE = 10 V, IC = 30 mA

|      | 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

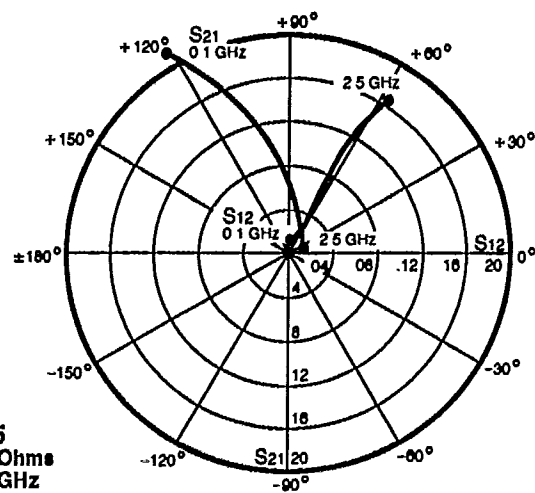
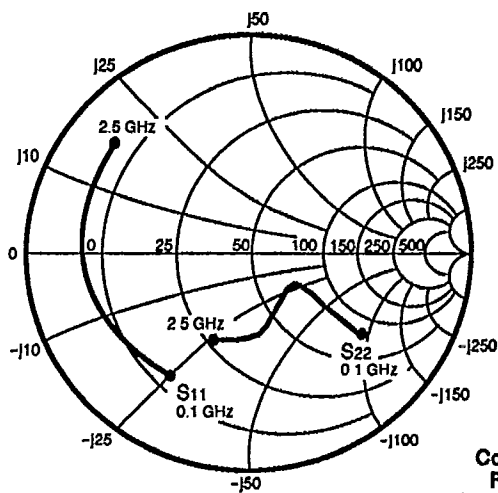
|      | S11 |      | S21   |     | S12 |    | S22 |      |
|------|-----|------|-------|-----|-----|----|-----|------|
| 100  | .29 | -104 | 15.31 | 110 | .02 | 63 | .59 | -26  |
| 200  | .25 | -135 | 8.44  | 93  | .04 | 68 | .51 | -18  |
| 500  | .27 | -167 | 3.64  | 69  | .11 | 67 | .48 | -46  |
| 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 |