

NEC's NPN SILICON HIGH FREQUENCY TRANSISTOR

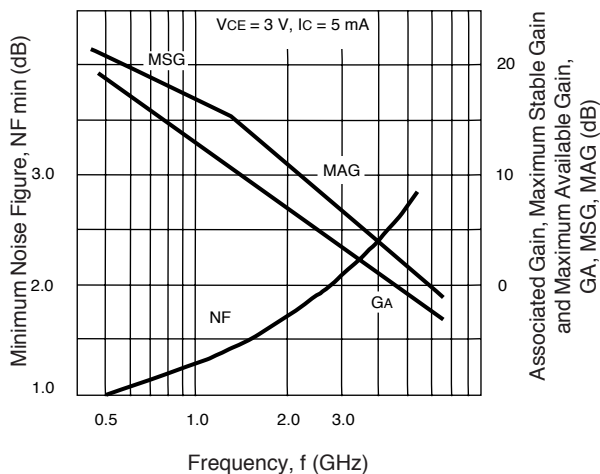
FEATURES

- **HIGH GAIN BANDWIDTH PRODUCT:** $f_T = 8 \text{ GHz}$
- **LOW NOISE FIGURE:**
1.2 dB at 1 GHz
1.6 dB at 2 GHz
- **HIGH ASSOCIATED GAIN:**
15 dB at 1 GHz
12 dB at 2 GHz
- **LOW COST**

DESCRIPTION

NEC's NE681 series of NPN epitaxial silicon transistors are designed for low noise, high gain, low cost amplifier applications. Both the chip and micro-x versions are suitable for amplifier applications up to 4 GHz. The NE681 die is also available in six different low cost plastic surface mount package styles. NE681's unique device characteristics allow you to use a single matching point to simultaneously achieve both low noise and high gain.

**NOISE FIGURE, GAIN MSG
AND MAG vs. FREQUENCY**



| | |
|--|---|
|  00 (CHIP) |  35 (MICRO-X) |
|  18 (SOT 343 STYLE) |  19 (3 PIN ULTRA SUPER MINI MOLD) |
|  30 (SOT 323 STYLE) |  33 (SOT 23 STYLE) |
|  39 (SOT 143 STYLE) |  39R (SOT 143R STYLE) |

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ELECTRICAL CHARACTERISTICS (T_A = 25°C)

| PART NUMBER EIAJ ¹ REGISTERED NUMBER PACKAGE OUTLINE | | | NE68100 00 (CHIP) | | | NE68118 2SC5012 18 | | | NE68119 2SC5007 19 | | | NE68130 2SC4227 30 | | |
|---|--|------------|----------------------|-----|-----|--------------------------|------|-----|--------------------------|------|------|--------------------------|------|-----|
| 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 V _{CE} = 3 V, I _C = 7 mA | GHz GHz | | 9.0 | | | 9.0 | | | 7.0 | | | 7.0 | |
| NF | Noise Figure at V _{CE} = 8 V, I _C = 7 mA, f = 1 GHz f = 2 GHz | dB dB | | 1.6 | 2.3 | | 1.2 | 2.5 | | 1.4 | 1.8 | | 1.5 | 1.6 |
| GNF | Associated Gain at V _{CE} = 8 V, I _C = 7 mA, f = 1 GHz f = 2 GHz | dB dB | | 12 | | | 14 | | | 14 | 10 | | 13.5 | 9 |
| IS _{21E} I ² | Insertion Power Gain at V _{CE} = 8 V, I _C = 20 mA, f = 1 GHz f = 2 GHz | dB dB | 9 | 17 | 11 | 13 | 15 | 9 | | 14 | 8 | | 13 | 7.5 |
| h _{FE} | Forward Current Gain ² at V _{CE} = 8 V, I _C = 20 mA V _{CE} = 3 V, I _C = 7 mA | | 50 | 100 | 250 | 50 | 100 | 250 | 80 | | 160 | 40 | | 240 |
| I _{CBO} | Collector Cutoff Current at V _{CB} = 10 V, I _E = 0 mA | μA | | | 1.0 | | | 1.0 | | | 1.0 | | | 1.0 |
| I _{EBO} | Emitter Cutoff Current at V _{EB} = 1 V, I _C = 0 mA | μA | | | 1.0 | | | 1.0 | | | 1.0 | | | 1.0 |
| C _{RE} ³ | Feedback Capacitance at V _{CB} = 3 V, I _E = 0 mA, f = 1 MHz V _{CB} = 10 V, I _E = 0 mA, f = 1 MHz | pF pF | | 0.2 | 0.7 | | 0.25 | 0.8 | | 0.45 | 0.9 | | 0.45 | 0.9 |
| R _{TH} (J-A) | Thermal Resistance (Junction to Ambient) | °C/W | | | 80 | | | 833 | | | 1000 | | | 833 |
| P _T | Total Power Dissipation | mW | | | 600 | | | 150 | | | 100 | | | 150 |

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

| PART NUMBER EIAJ ¹ REGISTERED NUMBER PACKAGE OUTLINE | | | NE68133 2SC3583 33 | | | NE68135 2SC3604 35 | | | NE68139/39R 2SC4094 39 | | | |
|---|--|------------|--------------------------|------|-----------|--------------------------|-----|-----|------------------------------|------|------|-----|
| SYMBOLS | PARAMETERS AND CONDITIONS | UNITS | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | |
| f _T | Gain Bandwidth Product at V _{CE} = 8 V, I _C = 20 mA V _{CE} = 3 V, I _C = 7 mA | GHz GHz | | 9.0 | | | 9.0 | | | 9.0 | | |
| NF | Noise Figure at V _{CE} = 8 V, I _C = 7 mA, f = 1 GHz f = 2 GHz | dB dB | | 1.2 | 2 | | | | 1.6 | 2.3 | 1.2 | 2 |
| GNF | Associated Gain at V _{CE} = 8 V, I _C = 7 mA, f = 1 GHz f = 2 GHz | dB dB | | 13 | | | | | 12 | | 13.5 | |
| IS _{21E} I ² | Insertion Power Gain at V _{CE} = 8 V, I _C = 20 mA, f = 1 GHz f = 2 GHz | dB dB | | 11 | 12.5 7 | 9 | 11 | | | | 15 | 8.5 |
| h _{FE} | Forward Current Gain ² at V _{CE} = 8 V, I _C = 20 mA V _{CE} = 3 V, I _C = 7 mA | | 50 | 100 | 250 | 50 | 100 | 250 | 50 | 100 | 200 | |
| I _{CBO} | Collector Cutoff Current at V _{CB} = 10 V, I _E = 0 mA | μA | | | 1.0 | | | 1.0 | | | 1.0 | |
| I _{EBO} | Emitter Cutoff Current at V _{EB} = 1 V, I _C = 0 mA | μA | | | 1.0 | | | 1.0 | | | 1.0 | |
| C _{RE} ³ | Feedback Capacitance at V _{CB} = 10 V, I _E = 0 mA, f = 1 MHz | pF | | 0.35 | 0.9 | | 0.2 | 0.7 | | 0.25 | 0.8 | |
| R _{TH} (J-A) | Thermal Resistance (Junction to Ambient) | °C/W | | | 625 | | | 590 | | | 625 | |
| P _T | Total Power Dissipation | mW | | | 200 | | | 295 | | | 200 | |

Notes:

1. Electronic Industrial Association of Japan.
2. Pulsed (PW ≤ 350 ms, duty cycle ≤ 2 %).
3. The emitter terminal should be connected to the ground terminal of the 3 terminal capacitance bridge.

ABSOLUTE MAXIMUM RATINGS¹ (T_A = 25°C)

| SYMBOLS | PARAMETERS | UNITS | RATINGS |
|------------------|--------------------------------|-------|--------------------------|
| V _{CB0} | Collector to Base Voltage | V | 20 |
| V _{CE0} | Collector to Emitter Voltage | V | 10 |
| V _{EB0} | Emitter to Base Voltage | V | 1.5 |
| I _c | Collector Current | mA | 65 |
| T _J | Operating Junction Temperature | °C | 150 ² |
| T _{STG} | Storage Temperature | °C | -55 to +150 ³ |

Notes:

1. Operation in excess of any one of these parameters may result in permanent damage.
2. T_J for NE68135 and NE68100 is 200°C.
3. Maximum storage temperature for the NE68135 is -65 to +150°C.

NE68119

TYPICAL NOISE PARAMETERS (T_A = 25°C)

| FREQ. (MHz) | NF _{OPT} (dB) | G _A (dB) | Γ _{OPT} | | Rn/50 |
|---|---------------------------|------------------------|------------------|------|-------|
| | | | MAG | ANG | |
| V_{CE} = 2.5 V, I_c = 0.3 mA | | | | | |
| 500 | 1.24 | 9.26 | 0.73 | 42 | 1.70 |
| 800 | 1.67 | 6.95 | 0.74 | 72 | 1.01 |
| 1000 | 2.18 | 6.02 | 0.70 | 90 | 0.78 |
| V_{CE} = 2.5 V, I_c = 1 mA | | | | | |
| 500 | 0.97 | 13.86 | 0.66 | 43 | 0.46 |
| 800 | 1.19 | 9.12 | 0.59 | 48 | 0.35 |
| 1000 | 1.31 | 10.09 | 0.56 | 89 | 0.30 |
| 1500 | 1.71 | 7.99 | 0.50 | 131 | 0.16 |
| V_{CE} = 2.5 V, I_c = 3 mA | | | | | |
| 500 | 0.92 | 17.19 | 0.49 | 39 | 0.28 |
| 800 | 1.02 | 14.23 | 0.40 | 68 | 0.17 |
| 1000 | 1.11 | 12.78 | 0.38 | 87 | 0.14 |
| 1500 | 1.42 | 10.30 | 0.39 | 134 | 0.08 |
| 2000 | 1.82 | 8.24 | 0.36 | 165 | 0.11 |
| V_{CE} = 3 V, I_c = 5 mA | | | | | |
| 500 | 1.00 | 19.00 | 0.37 | 43 | 0.20 |
| 800 | 1.10 | 15.57 | 0.31 | 71 | 0.15 |
| 1000 | 1.19 | 13.91 | 0.30 | 89 | 0.13 |
| 1500 | 1.40 | 11.25 | 0.33 | 139 | 0.09 |
| 2000 | 1.70 | 9.08 | 0.32 | 166 | 0.11 |
| 2500 | 2.05 | 7.62 | 0.36 | -163 | 0.13 |
| V_{CE} = 8 V, I_c = 7 mA | | | | | |
| 500 | 1.10 | 20.30 | 0.36 | 39 | 0.22 |
| 800 | 1.20 | 16.82 | 0.28 | 64 | 0.16 |
| 1000 | 1.30 | 15.10 | 0.28 | 81 | 0.14 |
| 1500 | 1.50 | 12.35 | 0.28 | 130 | 0.11 |
| 2000 | 1.77 | 10.21 | 0.28 | 158 | 0.12 |
| 2500 | 2.10 | 8.85 | 0.33 | -166 | 0.14 |
| 3000 | 2.40 | 7.86 | 0.44 | -141 | 0.16 |

NE68100

TYPICAL NOISE PARAMETERS (T_A = 25°C)

| FREQ. (MHz) | NF _{OPT} (dB) | G _A (dB) | Γ _{OPT} | | Rn/50 |
|---|---------------------------|------------------------|------------------|------|-------|
| | | | MAG | ANG | |
| V_{CE} = 8 V, I_c = 7 mA | | | | | |
| 500 | 1.3 | 26.42 | 0.20 | 91 | 0.20 |
| 1000 | 1.45 | 20.54 | 0.20 | 148 | 0.21 |
| 2000 | 2.1 | 14.41 | 0.22 | 178 | 0.51 |
| 4000 | 3.25 | 7.76 | 0.42 | -115 | 0.85 |

NE68130

TYPICAL NOISE PARAMETERS (T_A = 25°C)

| FREQ. (MHz) | NF _{OPT} (dB) | G _A (dB) | Γ _{OPT} | | Rn/50 |
|---|---------------------------|------------------------|------------------|------|-------|
| | | | MAG | ANG | |
| V_{CE} = 2.5 V, I_c = 0.3 mA | | | | | |
| 500 | 1.48 | 10.23 | 0.74 | 43 | 1.35 |
| 800 | 1.90 | 10.15 | 0.72 | 79 | 0.92 |
| 1000 | 2.15 | 9.00 | 0.69 | 99 | 0.60 |
| 1500 | 2.70 | 4.46 | 0.66 | 126 | 0.38 |
| V_{CE} = 2.5 V, I_c = 1 mA | | | | | |
| 500 | 1.10 | 14.69 | 0.65 | 45 | 0.42 |
| 800 | 1.26 | 12.73 | 0.60 | 80 | 0.30 |
| 1000 | 1.40 | 11.29 | 0.56 | 99 | 0.24 |
| 1500 | 1.80 | 7.40 | 0.53 | 123 | 0.17 |
| 2000 | 2.22 | 6.14 | 0.47 | 166 | 0.12 |
| 2500 | 2.75 | 4.89 | 0.49 | -166 | 0.08 |
| V_{CE} = 2.5 V, I_c = 3 mA | | | | | |
| 500 | 1.00 | 17.28 | 0.47 | 44 | 0.25 |
| 800 | 1.06 | 14.35 | 0.44 | 83 | 0.21 |
| 1000 | 1.16 | 12.69 | 0.43 | 100 | 0.17 |
| 1500 | 1.46 | 9.50 | 0.39 | 130 | 0.12 |
| 2000 | 1.80 | 7.70 | 0.35 | 177 | 0.11 |
| 2500 | 2.15 | 6.03 | 0.35 | -177 | 0.09 |
| V_{CE} = 8 V, I_c = 7mA | | | | | |
| 500 | 1.30 | 20.34 | 0.29 | 50 | 0.27 |
| 1000 | 1.40 | 13.96 | 0.25 | 84 | 0.18 |
| 2000 | 1.80 | 8.56 | 0.25 | 155 | 0.16 |
| 3000 | 2.50 | 5.64 | 0.48 | -167 | 0.10 |
| 4000 | 3.60 | 4.50 | 0.67 | -135 | 0.20 |

NE68135

TYPICAL NOISE PARAMETERS (T_A = 25°C)

| FREQ. (MHz) | NF _{OPT} (dB) | G _A (dB) | Γ _{OPT} | | Rn/50 |
|---|---------------------------|------------------------|------------------|------|-------|
| | | | MAG | ANG | |
| V_{CE} = 8 V, I_c = 7 mA | | | | | |
| 1000 | 1.1 | 17.33 | 0.28 | 71 | 0.22 |
| 2000 | 1.6 | 13.60 | 0.37 | 160 | 0.15 |
| 4000 | 3.4 | 9.25 | 0.51 | -139 | 0.27 |

NE68133

TYPICAL NOISE PARAMETERS (T_A = 25°C)

| FREQ. (MHz) | NF _{OPT} (dB) | G _A (dB) | Γ _{OPT} | | Rn/50 |
|---|---------------------------|------------------------|------------------|-----|-------|
| | | | MAG | ANG | |
| V_{CE} = 2.5 V, I_C = 0.3 mA | | | | | |
| 500 | 1.21 | 12.45 | 0.75 | 47 | 1.15 |
| 800 | 1.69 | 7.72 | 0.74 | 72 | 0.97 |
| 1000 | 1.95 | 5.96 | 0.68 | 88 | 0.71 |
| 1500 | 2.52 | 3.12 | 0.63 | 122 | 0.34 |
| V_{CE} = 2.5 V, I_C = 1.0 mA | | | | | |
| 500 | .92 | 14.52 | 0.68 | 47 | 0.42 |
| 800 | 1.20 | 10.57 | 0.63 | 70 | 0.34 |
| 1000 | 1.35 | 9.29 | 0.57 | 87 | 0.30 |
| 1500 | 1.71 | 6.53 | 0.50 | 120 | 0.17 |
| 2000 | 2.00 | 5.53 | 0.44 | 168 | 0.11 |
| V_{CE} = 2.5 V, I_C = 3 mA | | | | | |
| 500 | 0.86 | 16.37 | 0.54 | 47 | 0.24 |
| 800 | 1.00 | 12.41 | 0.51 | 67 | 0.20 |
| 1000 | 1.08 | 11.07 | 0.46 | 86 | 0.18 |
| 1500 | 1.25 | 8.61 | 0.36 | 128 | 0.12 |
| 2000 | 1.40 | 6.99 | 0.35 | 172 | 0.10 |

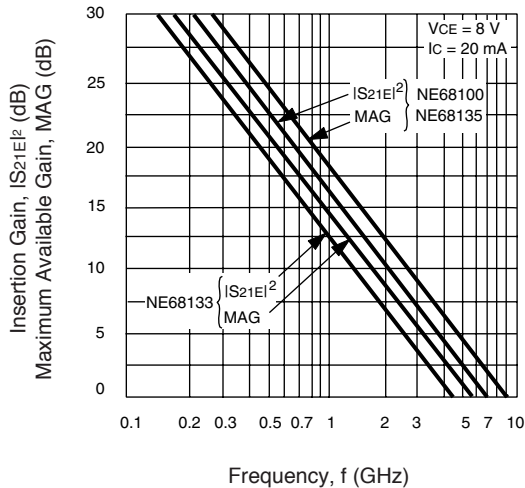
NE68139

TYPICAL NOISE PARAMETERS (T_A = 25°C)

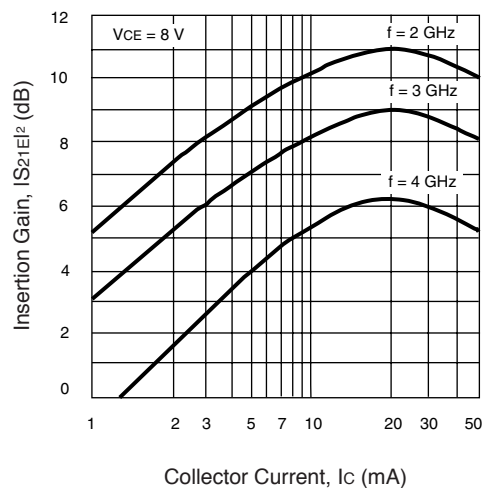
| FREQ. (MHz) | NF _{OPT} (dB) | G _A (dB) | Γ _{OPT} | | Rn/50 |
|---|---------------------------|------------------------|------------------|------|-------|
| | | | MAG | ANG | |
| V_{CE} = 2.5 V, I_C = 0.3 mA | | | | | |
| 500 | 1.20 | 14.10 | 0.78 | 47 | 1.28 |
| 800 | 1.45 | 8.42 | 0.75 | 72 | 0.84 |
| 1000 | 1.67 | 8.37 | 0.68 | 95 | 0.56 |
| V_{CE} = 2.5 V, I_C = 1 mA | | | | | |
| 500 | 0.90 | 15.71 | 0.63 | 44 | 0.43 |
| 800 | 1.10 | 12.30 | 0.56 | 72 | 0.26 |
| 1000 | 1.26 | 11.66 | 0.53 | 98 | 0.20 |
| 1500 | 1.70 | 8.85 | 0.49 | 145 | 0.12 |
| 2000 | 2.20 | 7.12 | 0.57 | 178 | 0.07 |
| V_{CE} = 2.5 V, I_C = 3 mA | | | | | |
| 500 | 0.88 | 18.20 | 0.45 | 44 | 0.25 |
| 800 | 1.00 | 14.62 | 0.39 | 73 | 0.19 |
| 1000 | 1.08 | 13.29 | 0.37 | 99 | 0.16 |
| 1500 | 1.30 | 10.54 | 0.35 | 151 | 0.09 |
| 2000 | 1.80 | 8.60 | 0.43 | -177 | 0.07 |
| V_{CE} = 8 V, I_C = 7 mA | | | | | |
| 500 | 1.15 | 20.50 | 0.26 | 42 | 0.17 |
| 1000 | 1.25 | 15.62 | 0.16 | 133 | 0.14 |
| 1500 | 1.4 | 12.49 | 0.20 | 176 | 0.09 |
| 2000 | 1.6 | 10.48 | 0.31 | -165 | 0.14 |
| 3000 | 2.15 | 8.00 | 0.53 | -123 | 0.48 |
| 4000 | 3.0 | 6.81 | 0.71 | -101 | 0.90 |

TYPICAL PERFORMANCE CURVES (T_A = 25°C)

FORWARD INSERTION GAIN AND MAXIMUM AVAILABLE GAIN vs. FREQUENCY

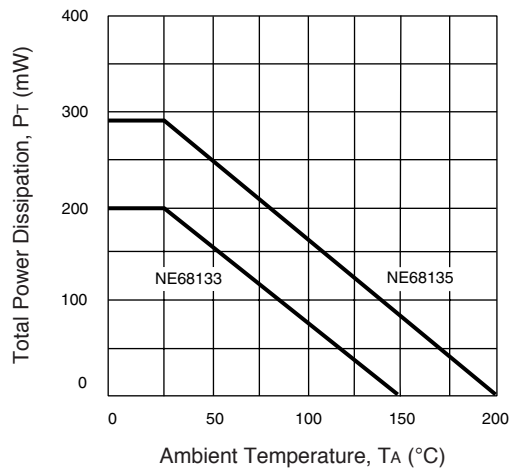


NE68100 & NE68135 INSERTION GAIN vs. COLLECTOR CURRENT

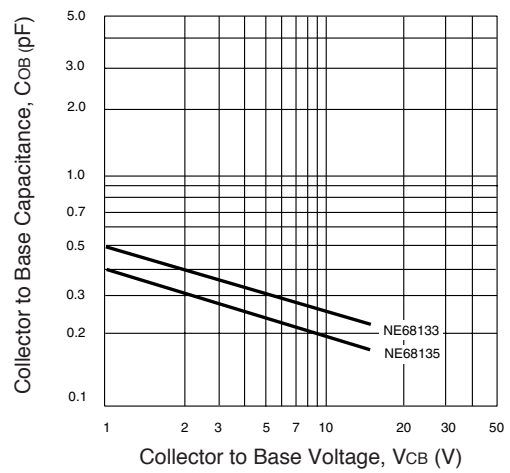


TYPICAL PERFORMANCE CURVES (TA = 25°C)

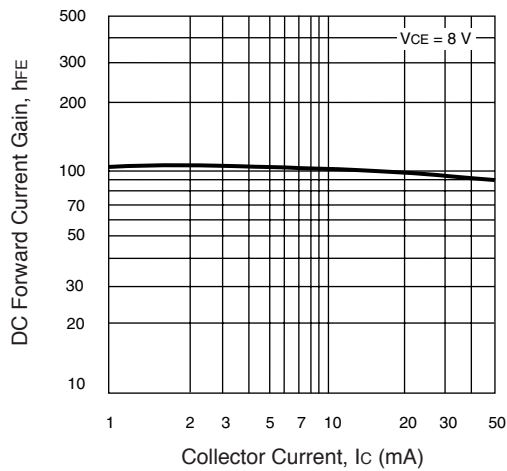
DC POWER DERATING CURVES



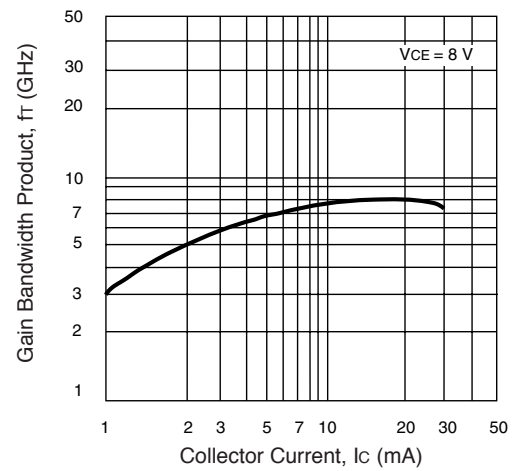
COLLECTOR TO BASE CAPACITANCE vs. COLLECTOR TO BASE VOLTAGE



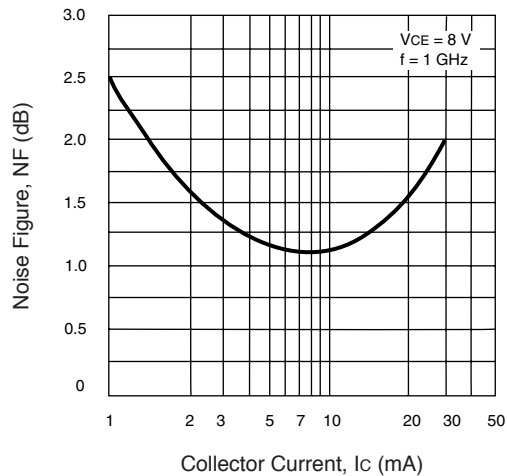
FORWARD CURRENT GAIN vs. COLLECTOR CURRENT



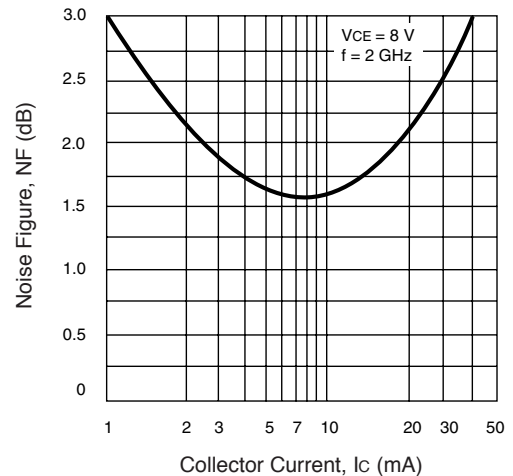
GAIN BANDWIDTH PRODUCT vs. COLLECTOR CURRENT



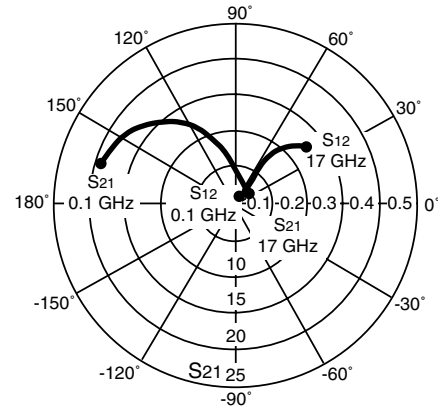
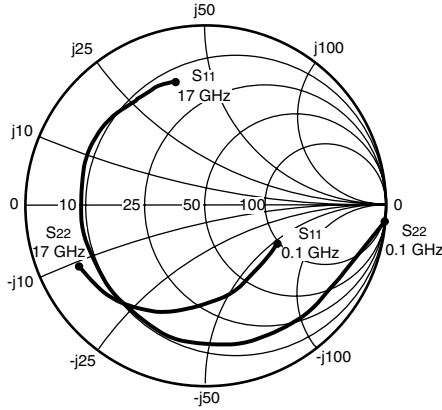
NE68133 NOISE FIGURE vs. COLLECTOR CURRENT



NE68100 & NE68135 NOISE FIGURE vs. COLLECTOR CURRENT



TYPICAL COMMON EMITTER SCATTERING PARAMETERS



Coordinates in Ohms
Frequency in GHz
(VCE = 8 V, IC = 7 mA)

NE68100

VCE = 8 V, IC = 7 mA

| FREQUENCY (MHz) | S11 | | S21 | | S12 | | S22 | | K | MAG ¹ (dB) |
|--------------------|-------|--------|--------|-------|-------|------|-------|--------|------|--------------------------|
| | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG | | |
| 100 | 0.827 | -20.8 | 19.513 | 163.9 | 0.012 | 88.3 | 0.964 | -7.0 | 0.03 | 32.1 |
| 200 | 0.809 | -49.5 | 17.981 | 151.0 | 0.022 | 65.5 | 0.894 | -16.8 | 0.13 | 29.1 |
| 500 | 0.742 | -101.1 | 12.631 | 123.0 | 0.038 | 42.2 | 0.691 | -27.4 | 0.28 | 25.2 |
| 1000 | 0.701 | -139.2 | 7.498 | 101.5 | 0.047 | 36.7 | 0.536 | -29.0 | 0.47 | 22.0 |
| 1500 | 0.689 | -156.6 | 5.182 | 90.4 | 0.049 | 33.0 | 0.483 | -28.6 | 0.71 | 20.2 |
| 2000 | 0.686 | -167.2 | 3.959 | 82.0 | 0.053 | 35.0 | 0.461 | -29.2 | 0.88 | 18.7 |
| 3000 | 0.687 | 179.8 | 2.687 | 69.7 | 0.061 | 45.9 | 0.447 | -33.6 | 1.11 | 14.4 |
| 4000 | 0.693 | 172.2 | 2.048 | 59.1 | 0.071 | 48.7 | 0.449 | -40.6 | 1.21 | 11.8 |
| 5000 | 0.699 | 166.6 | 1.662 | 49.8 | 0.081 | 53.2 | 0.454 | -48.0 | 1.27 | 10.0 |
| 6000 | 0.708 | 162.1 | 1.431 | 41.1 | 0.096 | 57.0 | 0.473 | -57.1 | 1.15 | 9.4 |
| 7000 | 0.717 | 157.0 | 1.250 | 31.7 | 0.116 | 56.6 | 0.490 | -66.8 | 0.99 | 10.3 |
| 8000 | 0.721 | 151.7 | 1.105 | 23.3 | 0.125 | 56.9 | 0.519 | -76.0 | 0.97 | 9.5 |
| 9000 | 0.725 | 145.5 | 0.989 | 14.2 | 0.146 | 55.9 | 0.549 | -86.4 | 0.83 | 8.3 |
| 10000 | 0.726 | 137.6 | 0.868 | 5.9 | 0.169 | 54.9 | 0.582 | -96.0 | 0.74 | 7.1 |
| 11000 | 0.724 | 131.2 | 0.773 | -2.0 | 0.179 | 51.9 | 0.621 | -104.8 | 0.71 | 6.4 |
| 12000 | 0.722 | 123.6 | 0.673 | -9.7 | 0.192 | 49.0 | 0.663 | -114.1 | 0.69 | 5.4 |

VCE = 8 V, IC = 20 mA

| | | | | | | | | | | |
|-------|-------|--------|--------|-------|-------|------|-------|--------|------|------|
| 100 | 0.665 | -47.0 | 38.130 | 154.1 | 0.011 | 90.0 | 0.885 | -15.0 | 0.01 | 35.4 |
| 200 | 0.664 | -85.3 | 31.089 | 135.9 | 0.017 | 70.3 | 0.753 | -26.0 | 0.12 | 32.6 |
| 500 | 0.663 | -135.8 | 16.975 | 108.9 | 0.025 | 45.4 | 0.504 | -30.8 | 0.45 | 28.3 |
| 1000 | 0.663 | -161.1 | 9.066 | 93.2 | 0.028 | 49.5 | 0.404 | -27.0 | 0.82 | 25.1 |
| 1500 | 0.667 | -171.7 | 6.113 | 84.9 | 0.036 | 49.6 | 0.377 | -26.3 | 0.97 | 22.3 |
| 2000 | 0.669 | -178.4 | 4.627 | 78.3 | 0.042 | 53.2 | 0.369 | -26.6 | 1.10 | 18.5 |
| 3000 | 0.676 | 172.7 | 3.112 | 67.9 | 0.054 | 59.2 | 0.361 | -31.6 | 1.25 | 14.6 |
| 4000 | 0.686 | 167.3 | 2.361 | 58.6 | 0.071 | 62.6 | 0.362 | -38.5 | 1.21 | 12.5 |
| 5000 | 0.693 | 162.6 | 1.913 | 50.1 | 0.086 | 63.5 | 0.372 | -45.8 | 1.19 | 10.8 |
| 6000 | 0.705 | 159.0 | 1.643 | 42.2 | 0.103 | 65.1 | 0.386 | -55.5 | 1.08 | 10.3 |
| 7000 | 0.719 | 154.5 | 1.433 | 33.3 | 0.123 | 63.2 | 0.405 | -65.0 | 0.94 | 10.7 |
| 8000 | 0.727 | 149.4 | 1.266 | 25.4 | 0.133 | 60.6 | 0.433 | -74.2 | 0.91 | 9.8 |
| 9000 | 0.726 | 143.5 | 1.134 | 16.7 | 0.153 | 60.4 | 0.464 | -84.5 | 0.84 | 8.7 |
| 10000 | 0.733 | 135.9 | 1.001 | 8.4 | 0.171 | 57.3 | 0.500 | -94.4 | 0.76 | 7.7 |
| 11000 | 0.732 | 129.4 | 0.897 | 0.5 | 0.185 | 53.9 | 0.546 | -103.2 | 0.71 | 6.9 |
| 12000 | 0.728 | 122.1 | 0.787 | -7.1 | 0.197 | 51.8 | 0.587 | -112.6 | 0.72 | 6.0 |

S-Parameters include bond wires.

BASE: Total 1 wire (s), 1 per bond pad, 0.0122" (309 μm) long each wire.

COLLECTOR: Total 1 wire (s), 1 per bond pad, 0.008" (203 μm) long each wire.

EMITTER: Total 2 wire (s), 1 per side, 0.0194" (494 μm) long each wire.

WIRE: 0.0007" (17.7 μm) dia., gold.

Note:

1. Gain Calculations:

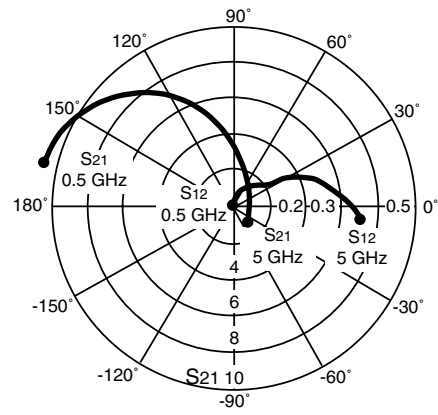
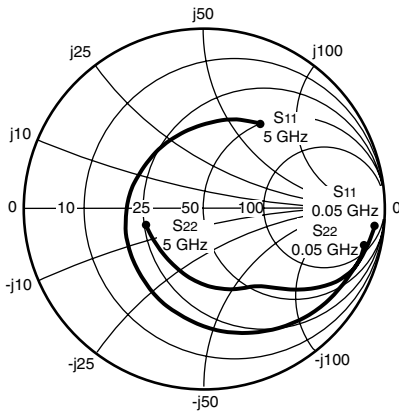
$$MAG = \frac{|S_{21}|}{|S_{12}|} (K \pm \sqrt{K^2 - 1})$$

When $K \leq 1$, MAG is undefined and MSG values are used. $MSG = \frac{|S_{21}|}{|S_{12}|}$, $K = \frac{1 + |\Delta|^2 - |S_{11}|^2 - |S_{22}|^2}{2 |S_{12}| |S_{21}|}$, $\Delta = S_{11} S_{22} - S_{21} S_{12}$

MAG = Maximum Available Gain

MSG = Maximum Stable Gain

TYPICAL COMMON EMITTER SCATTERING PARAMETERS



Coordinates in Ohms
Frequency in GHz
(V_{CE} = 2.5 V, I_C = 3 mA)

NE68119

V_{CE} = 2.5 V, I_C = 0.3 mA

| FREQUENCY (MHz) | S ₁₁ | | S ₂₁ | | S ₁₂ | | S ₂₂ | | K | MAG ¹ (dB) |
|--------------------|-----------------|--------|-----------------|-------|-----------------|-------|-----------------|-------|------|--------------------------|
| | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG | | |
| 50 | 0.995 | -6.1 | 1.283 | 174.1 | 0.017 | 88.1 | 0.997 | -1.1 | 0.02 | 18.8 |
| 100 | 0.992 | -11.9 | 1.081 | 170.4 | 0.027 | 80.9 | 0.995 | -4.5 | 0.06 | 16.0 |
| 200 | 0.981 | -23.5 | 1.038 | 158.4 | 0.052 | 74.0 | 0.991 | -9.3 | 0.11 | 13.0 |
| 300 | 0.967 | -35.3 | 1.021 | 149.2 | 0.078 | 65.0 | 0.989 | -14.3 | 0.15 | 11.2 |
| 400 | 0.950 | -46.1 | 0.985 | 139.2 | 0.096 | 58.4 | 0.979 | -18.2 | 0.20 | 10.1 |
| 500 | 0.929 | -57.0 | 0.952 | 130.0 | 0.114 | 52.4 | 0.962 | -22.5 | 0.23 | 9.2 |
| 600 | 0.915 | -67.0 | 0.936 | 121.0 | 0.130 | 44.5 | 0.948 | -26.4 | 0.30 | 8.6 |
| 700 | 0.892 | -77.0 | 0.888 | 112.7 | 0.144 | 38.5 | 0.937 | -30.1 | 0.33 | 7.9 |
| 800 | 0.874 | -86.0 | 0.869 | 105.0 | 0.153 | 32.7 | 0.928 | -33.9 | 0.36 | 7.5 |
| 900 | 0.853 | -94.5 | 0.808 | 97.2 | 0.160 | 27.3 | 0.916 | -37.1 | 0.42 | 7.0 |
| 1000 | 0.838 | -102.9 | 0.784 | 90.6 | 0.165 | 21.8 | 0.908 | -40.5 | 0.45 | 6.8 |
| 1500 | 0.770 | -139.2 | 0.652 | 61.2 | 0.169 | 1.6 | 0.869 | -54.5 | 0.66 | 5.9 |
| 2000 | 0.723 | -170.6 | 0.564 | 39.0 | 0.146 | -12.7 | 0.842 | -66.5 | 0.95 | 5.9 |
| 3000 | 0.693 | 132.2 | 0.441 | 9.0 | 0.085 | 6.0 | 0.803 | -91.2 | 1.98 | 1.5 |

V_{CE} = 2.5 V, I_C = 1.0 mA

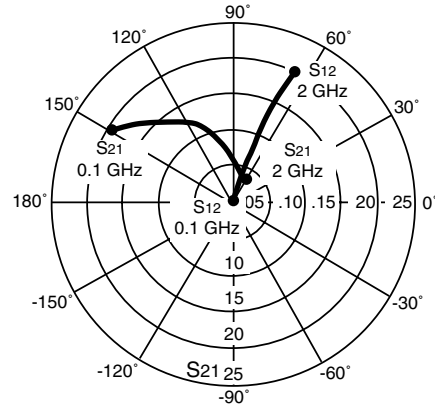
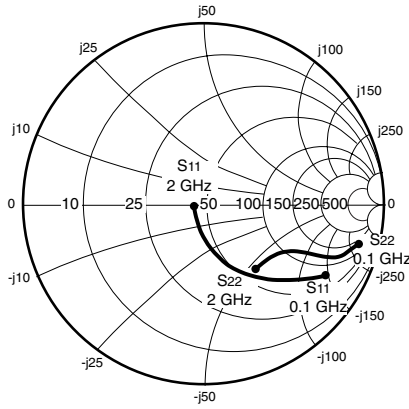
| | | | | | | | | | | |
|------|-------|--------|-------|-------|-------|------|-------|-------|------|------|
| 50 | 0.979 | -8.4 | 4.317 | 172.8 | 0.016 | 87.7 | 0.990 | -1.3 | 0.04 | 24.3 |
| 100 | 0.965 | -15.9 | 3.510 | 166.3 | 0.026 | 77.4 | 0.986 | -7.5 | 0.10 | 21.3 |
| 200 | 0.944 | -30.0 | 3.384 | 155.6 | 0.049 | 71.9 | 0.971 | -13.0 | 0.09 | 18.4 |
| 300 | 0.915 | -44.6 | 3.234 | 145.3 | 0.069 | 60.3 | 0.949 | -19.4 | 0.15 | 16.7 |
| 400 | 0.877 | -57.8 | 3.069 | 134.8 | 0.090 | 54.9 | 0.918 | -24.6 | 0.17 | 15.3 |
| 500 | 0.836 | -70.1 | 2.855 | 125.6 | 0.104 | 45.7 | 0.883 | -29.1 | 0.25 | 14.4 |
| 600 | 0.802 | -81.8 | 2.671 | 116.9 | 0.115 | 40.8 | 0.850 | -33.4 | 0.28 | 13.7 |
| 700 | 0.770 | -92.3 | 2.502 | 109.0 | 0.122 | 34.6 | 0.822 | -37.2 | 0.33 | 13.1 |
| 800 | 0.741 | -102.0 | 2.341 | 102.0 | 0.127 | 29.9 | 0.798 | -40.6 | 0.38 | 12.7 |
| 900 | 0.714 | -110.7 | 2.195 | 95.1 | 0.133 | 25.9 | 0.778 | -43.4 | 0.43 | 12.2 |
| 1000 | 0.694 | -118.7 | 2.041 | 89.4 | 0.135 | 21.6 | 0.762 | -46.4 | 0.48 | 11.8 |
| 1500 | 0.616 | -153.7 | 1.547 | 63.8 | 0.132 | 9.1 | 0.706 | -58.1 | 0.75 | 10.7 |
| 2000 | 0.572 | 177.3 | 1.255 | 43.4 | 0.124 | 6.7 | 0.672 | -68.2 | 1.07 | 8.4 |
| 3000 | 0.555 | 125.5 | 0.940 | 10.4 | 0.132 | 20.2 | 0.627 | -89.7 | 1.41 | 4.7 |

V_{CE} = 2.5 V, I_C = 3 mA

| | | | | | | | | | | |
|------|-------|--------|--------|-------|-------|------|-------|-------|------|------|
| 50 | 0.937 | -13.0 | 10.816 | 167.8 | 0.014 | 85.2 | 0.970 | -5.3 | 0.08 | 28.9 |
| 100 | 0.904 | -22.9 | 9.618 | 161.4 | 0.023 | 76.5 | 0.955 | -12.0 | 0.10 | 26.2 |
| 200 | 0.839 | -44.6 | 8.856 | 145.9 | 0.044 | 65.5 | 0.907 | -21.5 | 0.16 | 23.0 |
| 300 | 0.771 | -63.4 | 7.858 | 133.0 | 0.061 | 55.3 | 0.830 | -29.5 | 0.25 | 21.1 |
| 400 | 0.699 | -79.9 | 6.982 | 121.6 | 0.071 | 48.3 | 0.761 | -35.9 | 0.32 | 19.9 |
| 500 | 0.642 | -93.8 | 6.172 | 112.2 | 0.080 | 42.4 | 0.699 | -39.7 | 0.41 | 18.9 |
| 600 | 0.598 | -106.0 | 5.458 | 104.1 | 0.086 | 38.7 | 0.651 | -43.3 | 0.48 | 18.0 |
| 700 | 0.564 | -116.4 | 4.898 | 97.3 | 0.089 | 36.7 | 0.613 | -46.0 | 0.55 | 17.4 |
| 800 | 0.534 | -125.9 | 4.429 | 91.1 | 0.093 | 34.0 | 0.587 | -48.2 | 0.62 | 16.8 |
| 900 | 0.511 | -134.1 | 4.032 | 85.5 | 0.095 | 33.3 | 0.565 | -50.1 | 0.69 | 16.3 |
| 1000 | 0.494 | -141.6 | 3.696 | 80.6 | 0.099 | 32.1 | 0.549 | -52.3 | 0.74 | 15.7 |
| 1500 | 0.438 | -172.6 | 2.618 | 59.5 | 0.113 | 29.1 | 0.508 | -59.9 | 0.99 | 13.6 |
| 2000 | 0.409 | 162.4 | 2.042 | 41.8 | 0.130 | 28.7 | 0.485 | -67.6 | 1.15 | 9.6 |
| 3000 | 0.410 | 117.0 | 1.474 | 11.1 | 0.187 | 24.2 | 0.448 | -85.5 | 1.16 | 6.5 |

See note on next page.

TYPICAL COMMON EMITTER SCATTERING PARAMETERS



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

NE68133

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

| FREQUENCY (MHz) | S ₁₁ | | S ₂₁ | | S ₁₂ | | S ₂₂ | | K | MAG ¹ (dB) |
|--------------------|-----------------|--------|-----------------|-------|-----------------|------|-----------------|-------|------|--------------------------|
| | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG | | |
| 100 | 0.802 | -27.1 | 17.578 | 153.8 | 0.023 | 68.7 | 0.918 | -12.7 | 0.37 | 28.8 |
| 200 | 0.639 | -49.2 | 14.213 | 134.2 | 0.039 | 69.8 | 0.783 | -19.9 | 0.46 | 25.6 |
| 500 | 0.344 | -83.3 | 7.671 | 105.5 | 0.065 | 67.8 | 0.579 | -21.5 | 0.81 | 20.7 |
| 1000 | 0.170 | -113.4 | 4.126 | 86.7 | 0.109 | 73.5 | 0.491 | -17.7 | 1.01 | 15.2 |
| 1500 | 0.115 | -144.1 | 2.870 | 75.3 | 0.160 | 74.8 | 0.454 | -17.8 | 1.05 | 11.2 |
| 2000 | 0.098 | -176.3 | 2.254 | 66.2 | 0.212 | 74.7 | 0.438 | -16.9 | 1.04 | 9.0 |
| 3000 | 0.137 | 137.6 | 1.669 | 53.2 | 0.313 | 73.2 | 0.409 | -21.0 | 0.99 | 7.3 |

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

| | | | | | | | | | | |
|------|-------|--------|--------|-------|-------|------|-------|-------|------|------|
| 100 | 0.744 | -31.7 | 21.212 | 148.4 | 0.017 | 57.9 | 0.896 | -14.6 | 0.50 | 31.0 |
| 200 | 0.553 | -54.5 | 16.031 | 127.9 | 0.037 | 69.0 | 0.737 | -21.7 | 0.54 | 26.4 |
| 500 | 0.277 | -87.1 | 8.093 | 102.0 | 0.061 | 72.6 | 0.540 | -20.9 | 0.88 | 21.2 |
| 1000 | 0.134 | -115.8 | 4.284 | 85.3 | 0.109 | 76.3 | 0.461 | -17.0 | 1.04 | 14.7 |
| 1500 | 0.092 | -146.2 | 2.981 | 75.2 | 0.165 | 75.9 | 0.430 | -16.5 | 1.04 | 11.3 |
| 2000 | 0.079 | 180.0 | 2.350 | 66.5 | 0.217 | 75.2 | 0.413 | -16.8 | 1.03 | 9.3 |
| 3000 | 0.122 | 134.2 | 1.736 | 53.9 | 0.320 | 73.7 | 0.380 | -21.3 | 0.99 | 7.3 |

V_{CE} = 8 V, I_c = 20 mA

| | | | | | | | | | | |
|------|-------|--------|--------|-------|-------|------|-------|-------|------|------|
| 100 | 0.594 | -43.3 | 29.285 | 138.1 | 0.013 | 61.2 | 0.792 | -19.4 | 0.57 | 33.5 |
| 200 | 0.389 | -66.3 | 19.280 | 117.5 | 0.035 | 73.1 | 0.614 | -22.6 | 0.69 | 27.4 |
| 500 | 0.175 | -95.5 | 8.683 | 96.1 | 0.057 | 74.0 | 0.481 | -16.5 | 0.98 | 21.8 |
| 1000 | 0.089 | -127.5 | 4.512 | 82.3 | 0.110 | 79.6 | 0.440 | -13.2 | 1.03 | 15.1 |
| 1500 | 0.064 | -160.8 | 3.078 | 73.3 | 0.167 | 78.9 | 0.416 | -13.9 | 1.04 | 11.4 |
| 2000 | 0.070 | 167.0 | 2.406 | 64.9 | 0.221 | 74.9 | 0.404 | -13.8 | 1.02 | 9.5 |
| 3000 | 0.120 | 132.5 | 1.774 | 53.1 | 0.322 | 72.4 | 0.379 | -19.4 | 0.98 | 7.4 |

V_{CE} = 8 V, I_c = 30 mA

| | | | | | | | | | | |
|------|-------|--------|--------|-------|-------|------|-------|-------|------|------|
| 100 | 0.557 | -46.9 | 30.197 | 135.2 | 0.017 | 65.9 | 0.836 | -17.4 | 0.50 | 32.5 |
| 200 | 0.354 | -70.7 | 19.196 | 115.1 | 0.029 | 73.4 | 0.664 | -22.2 | 0.67 | 28.2 |
| 500 | 0.158 | -100.5 | 8.499 | 94.8 | 0.059 | 77.7 | 0.503 | -17.7 | 0.95 | 21.6 |
| 1000 | 0.080 | -136.1 | 4.363 | 81.7 | 0.111 | 80.7 | 0.455 | -14.3 | 1.03 | 14.9 |
| 1500 | 0.065 | -175.0 | 3.009 | 72.7 | 0.167 | 80.1 | 0.428 | -14.2 | 1.03 | 11.5 |
| 2000 | 0.076 | 156.0 | 2.348 | 65.0 | 0.219 | 77.1 | 0.415 | -14.2 | 1.03 | 9.2 |
| 3000 | 0.127 | 128.4 | 1.742 | 53.0 | 0.325 | 74.2 | 0.387 | -19.7 | 0.98 | 7.3 |

Note:

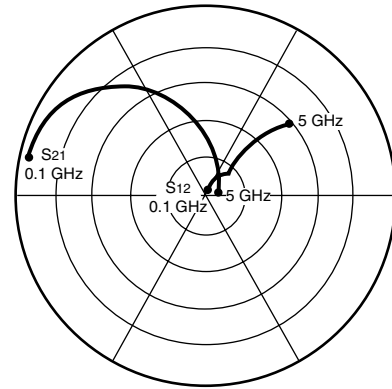
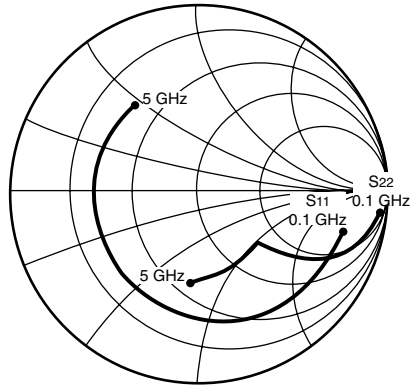
1. Gain Calculations:

$$MAG = \frac{|S_{21}|}{|S_{12}|} \left(K \pm \sqrt{K^2 - 1} \right). \text{ When } K \leq 1, \text{ MAG is undefined and MSG values are used. } MSG = \frac{|S_{21}|}{|S_{12}|}, K = \frac{1 + |\Delta|^2 - |S_{11}|^2 - |S_{22}|^2}{2 |S_{12}| |S_{21}|}, \Delta = S_{11} S_{22} - S_{21} S_{12}$$

MAG = Maximum Available Gain

MSG = Maximum Stable Gain

TYPICAL COMMON EMITTER SCATTERING PARAMETERS



Coordinates in Ohms
Frequency in GHz
(VCE = 8 V, Ic = 10 mA)

NE68135

VCE = 8 V, Ic = 7 mA

| FREQUENCY (MHz) | S11 | | S21 | | S12 | | S22 | | K | MAG ¹ (dB) |
|--------------------|------|--------|--------|-------|------|------|------|-------|------|--------------------------|
| | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG | | |
| 100 | .836 | -26.1 | 18.427 | 160.4 | .014 | 73.6 | .959 | -11.3 | 0.16 | 31.1 |
| 500 | .659 | -105.0 | 11.481 | 114.7 | .041 | 44.3 | .654 | -33.2 | 0.38 | 24.4 |
| 1000 | .585 | -146.1 | 6.625 | 90.3 | .051 | 38.3 | .512 | -38.5 | 0.68 | 21.1 |
| 1500 | .557 | -167.0 | 4.555 | 75.5 | .058 | 39.3 | .472 | -43.1 | 0.93 | 18.9 |
| 2000 | .562 | -180.0 | 3.507 | 63.9 | .068 | 41.3 | .462 | -49.4 | 1.02 | 16.4 |
| 3000 | .561 | 159.6 | 2.413 | 43.4 | .088 | 43.1 | .468 | -64.3 | 1.11 | 12.4 |
| 4000 | .562 | 142.8 | 1.854 | 25.1 | .113 | 41.9 | .490 | -80.4 | 1.07 | 10.6 |
| 5000 | .563 | 127.0 | 1.516 | 8.0 | .142 | 38.7 | .522 | -96.0 | 0.98 | 10.3 |

VCE = 8 V, Ic = 10 mA

| | | | | | | | | | | |
|------|------|--------|--------|-------|------|------|------|-------|------|------|
| 100 | .781 | -32.1 | 24.097 | 157.2 | .013 | 73.4 | .937 | -13.9 | 0.15 | 32.6 |
| 500 | .609 | -117.6 | 13.015 | 109.6 | .036 | 44.6 | .582 | -35.2 | 0.47 | 25.6 |
| 1000 | .558 | -154.7 | 7.233 | 87.5 | .045 | 43.2 | .457 | -38.5 | 0.79 | 22.0 |
| 1500 | .540 | -173.1 | 4.925 | 73.9 | .055 | 45.8 | .425 | -42.6 | 1.00 | 19.4 |
| 2000 | .547 | 175.3 | 3.778 | 62.9 | .067 | 47.6 | .420 | -48.8 | 1.05 | 16.1 |
| 3000 | .549 | 156.5 | 2.590 | 43.3 | .091 | 47.4 | .428 | -63.7 | 1.09 | 12.7 |
| 4000 | .551 | 140.6 | 1.990 | 25.5 | .119 | 44.2 | .452 | -79.7 | 1.05 | 10.9 |
| 5000 | .551 | 125.2 | 1.629 | 8.7 | .149 | 39.4 | .486 | -95.2 | 0.96 | 10.4 |

VCE = 8 V, Ic = 20 mA

| | | | | | | | | | | |
|------|------|--------|--------|-------|------|------|------|-------|------|------|
| 100 | .654 | -49.9 | 36.807 | 149.3 | .012 | 67.4 | .877 | -19.2 | 0.21 | 35.0 |
| 500 | .547 | -139.7 | 14.980 | 101.5 | .027 | 49.0 | .475 | -34.9 | 0.66 | 27.5 |
| 1000 | .535 | -168.1 | 7.916 | 83.2 | .038 | 53.7 | .392 | -35.7 | 0.95 | 23.2 |
| 1500 | .527 | -177.7 | 5.328 | 71.3 | .051 | 56.2 | .375 | -39.9 | 1.08 | 18.4 |
| 2000 | .534 | 168.5 | 4.072 | 61.1 | .065 | 56.6 | .376 | -46.5 | 1.09 | 16.2 |
| 3000 | .541 | 151.9 | 2.780 | 42.7 | .094 | 53.4 | .389 | -61.9 | 1.07 | 13.1 |
| 4000 | .544 | 137.2 | 2.131 | 25.5 | .124 | 47.8 | .415 | -78.1 | 1.01 | 11.6 |
| 5000 | .544 | 122.7 | 1.745 | 9.0 | .156 | 41.3 | .451 | -93.7 | 0.94 | 10.5 |

VCE = 8 V, Ic = 30 mA

| | | | | | | | | | | |
|------|------|--------|--------|-------|------|------|------|-------|------|------|
| 100 | .575 | -64.1 | 43.452 | 144.0 | .010 | 64.1 | .831 | -21.9 | 0.26 | 36.3 |
| 500 | .539 | -150.2 | 15.238 | 97.9 | .023 | 52.7 | .441 | -32.3 | 0.77 | 28.2 |
| 1000 | .537 | -173.7 | 7.926 | 81.2 | .036 | 58.9 | .381 | -32.9 | 1.01 | 22.7 |
| 1500 | .532 | 173.7 | 5.318 | 69.9 | .049 | 60.7 | .370 | -37.8 | 1.11 | 18.3 |
| 2000 | .541 | 165.5 | 4.058 | 60.1 | .064 | 60.2 | .374 | -44.9 | 1.09 | 16.1 |
| 3000 | .549 | 149.8 | 2.767 | 41.9 | .094 | 55.9 | .390 | -60.9 | 1.06 | 13.2 |
| 4000 | .552 | 135.7 | 2.118 | 24.9 | .125 | 49.8 | .416 | -77.4 | 1.00 | 12.1 |
| 5000 | .553 | 121.2 | 1.731 | 8.5 | .157 | 42.9 | .453 | -93.3 | 0.92 | 10.4 |

Note:

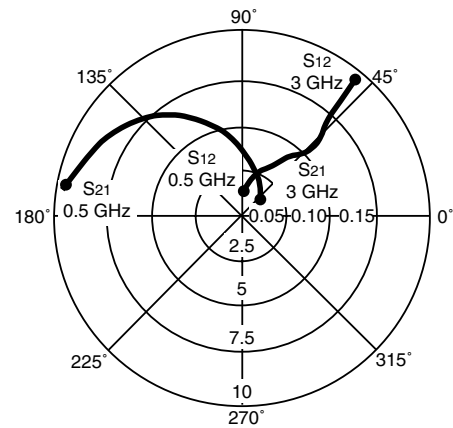
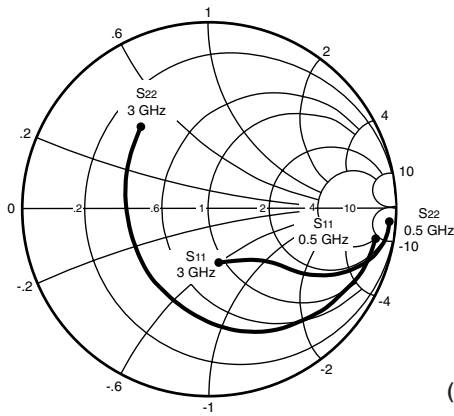
1. Gain Calculations:

$$MAG = \frac{|S_{21}|}{|S_{12}|} \left(K \pm \sqrt{K^2 - 1} \right). \text{ When } K \leq 1, \text{ MAG is undefined and MSG values are used. } MSG = \frac{|S_{21}|}{|S_{12}|}, K = \frac{1 + |\Delta|^2 - |S_{11}|^2 - |S_{22}|^2}{2 |S_{12}| |S_{21}|}, \Delta = S_{11} S_{22} - S_{21} S_{12}$$

MAG = Maximum Available Gain

MSG = Maximum Stable Gain

TYPICAL COMMON EMITTER SCATTERING PARAMETERS (TA = 25°C)



Coordinates in Ohms
Frequency in GHz
(VCE = 2.5 V, IC = 3 mA)

NE68139

VCE = 2.5 V, IC = 0.3 mA

| FREQUENCY (MHz) | S11 | | S21 | | S12 | | S22 | | K | MAG ¹ (dB) |
|--------------------|-------|--------|-------|-------|-------|------|-------|-------|------|--------------------------|
| | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG | | |
| 50 | 0.996 | -3.4 | 1.089 | 175.2 | 0.014 | 83.2 | 0.995 | -1.1 | 0.13 | 18.9 |
| 100 | 0.995 | -11.4 | 1.079 | 173.1 | 0.027 | 80.3 | 0.993 | -2.7 | 0.06 | 16.0 |
| 200 | 0.990 | -20.3 | 1.071 | 161.9 | 0.050 | 74.5 | 0.989 | -5.7 | 0.16 | 13.3 |
| 300 | 0.973 | -30.7 | 1.032 | 153.6 | 0.075 | 68.7 | 0.985 | -8.7 | 0.19 | 11.4 |
| 400 | 0.953 | -41.2 | 0.993 | 145.9 | 0.098 | 64.3 | 0.976 | -11.4 | 0.19 | 10.1 |
| 500 | 0.931 | -50.3 | 0.991 | 137.2 | 0.122 | 59.3 | 0.965 | -13.8 | 0.25 | 9.1 |
| 600 | 0.909 | -60.5 | 1.008 | 129.9 | 0.138 | 53.5 | 0.949 | -16.4 | 0.28 | 8.6 |
| 800 | 0.862 | -79.9 | 0.908 | 114.3 | 0.167 | 42.7 | 0.918 | -21.0 | 0.37 | 7.4 |
| 1000 | 0.819 | -98.5 | 0.871 | 101.2 | 0.184 | 33.4 | 0.888 | -25.0 | 0.45 | 6.8 |
| 1500 | 0.744 | -140.0 | 0.729 | 72.2 | 0.192 | 14.1 | 0.828 | -35.2 | 0.66 | 5.8 |
| 2000 | 0.732 | -173.0 | 0.632 | 51.7 | 0.155 | 3.4 | 0.802 | -46.3 | 0.85 | 5.0 |
| 3000 | 0.762 | 142.1 | 0.438 | 28.5 | 0.089 | 8.4 | 0.770 | -76.7 | 1.62 | 2.3 |

VCE = 2.5 V, IC = 1.0 mA

| | | | | | | | | | | |
|------|-------|--------|-------|-------|-------|------|-------|-------|------|------|
| 50 | 0.985 | -6.8 | 3.763 | 175.3 | 0.016 | 86.4 | 0.989 | -2.8 | 0.01 | 23.7 |
| 100 | 0.971 | -14.8 | 3.648 | 171.0 | 0.029 | 82.4 | 0.980 | -4.8 | 0.01 | 21.0 |
| 200 | 0.942 | -27.5 | 3.497 | 159.1 | 0.050 | 74.3 | 0.963 | -9.5 | 0.10 | 18.4 |
| 300 | 0.914 | -40.4 | 3.346 | 149.4 | 0.070 | 65.4 | 0.946 | -13.9 | 0.17 | 16.8 |
| 400 | 0.876 | -53.8 | 3.184 | 140.6 | 0.092 | 58.7 | 0.916 | -17.8 | 0.20 | 15.4 |
| 500 | 0.828 | -65.2 | 3.043 | 131.8 | 0.106 | 53.8 | 0.884 | -20.9 | 0.25 | 14.6 |
| 600 | 0.790 | -76.9 | 2.880 | 124.1 | 0.119 | 47.7 | 0.845 | -24.1 | 0.30 | 13.8 |
| 800 | 0.715 | -98.4 | 2.516 | 109.8 | 0.137 | 38.9 | 0.778 | -28.6 | 0.40 | 12.6 |
| 1000 | 0.663 | -117.6 | 2.237 | 98.4 | 0.145 | 32.3 | 0.726 | -31.9 | 0.49 | 11.9 |
| 1500 | 0.596 | -157.8 | 1.686 | 74.8 | 0.145 | 23.5 | 0.631 | -39.8 | 0.75 | 10.7 |
| 2000 | 0.600 | 173.8 | 1.346 | 56.9 | 0.130 | 24.6 | 0.583 | -48.9 | 1.04 | 8.9 |
| 3000 | 0.660 | 136.9 | 0.941 | 30.9 | 0.144 | 47.4 | 0.538 | -75.9 | 1.21 | 5.4 |

VCE = 2.5 V, IC = 3 mA

| | | | | | | | | | | |
|------|-------|--------|--------|-------|-------|------|-------|-------|------|------|
| 50 | 0.916 | -10.7 | 10.426 | 172.1 | 0.015 | 84.7 | 0.975 | -4.6 | 0.07 | 28.4 |
| 100 | 0.895 | -23.5 | 9.954 | 164.8 | 0.027 | 79.0 | 0.972 | -9.6 | 0.05 | 25.7 |
| 200 | 0.829 | -42.0 | 9.011 | 148.6 | 0.046 | 67.6 | 0.910 | -18.1 | 0.19 | 22.9 |
| 300 | 0.755 | -60.3 | 8.067 | 136.2 | 0.061 | 57.7 | 0.826 | -24.5 | 0.29 | 21.2 |
| 400 | 0.694 | -76.4 | 7.165 | 125.8 | 0.074 | 52.4 | 0.754 | -29.3 | 0.35 | 19.9 |
| 500 | 0.619 | -90.0 | 6.329 | 117.1 | 0.083 | 49.8 | 0.690 | -32.3 | 0.43 | 18.8 |
| 600 | 0.574 | -103.0 | 5.660 | 109.8 | 0.089 | 46.7 | 0.634 | -34.4 | 0.50 | 18.0 |
| 800 | 0.500 | -125.0 | 4.558 | 97.8 | 0.099 | 43.3 | 0.552 | -37.1 | 0.65 | 16.6 |
| 1000 | 0.470 | -143.4 | 3.815 | 88.7 | 0.106 | 42.0 | 0.496 | -38.6 | 0.77 | 15.6 |
| 1500 | 0.453 | -178.4 | 2.684 | 70.7 | 0.123 | 43.6 | 0.412 | -43.3 | 0.99 | 13.4 |
| 2000 | 0.481 | 159.4 | 2.078 | 56.4 | 0.141 | 47.3 | 0.362 | -51.3 | 1.11 | 9.7 |
| 3000 | 0.567 | 130.6 | 1.442 | 34.1 | 0.197 | 49.7 | 0.302 | -78.6 | 1.08 | 6.9 |

Note:

1. Gain Calculations:

$$MAG = \frac{|S_{21}|}{|S_{12}|} (K \pm \sqrt{K^2 - 1})$$

When $K \leq 1$, MAG is undefined and MSG values are used. $MSG = \frac{|S_{21}|}{|S_{12}|}$, $K = \frac{1 + |\Delta|^2 - |S_{11}|^2 - |S_{22}|^2}{2 |S_{12}| |S_{21}|}$, $\Delta = S_{11} S_{22} - S_{21} S_{12}$

MAG = Maximum Available Gain

MSG = Maximum Stable Gain

TYPICAL COMMON EMITTER SCATTERING PARAMETERS (T_A = 25°C)

NE68139

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

| FREQUENCY (MHz) | S ₁₁ | | S ₂₁ | | S ₁₂ | | S ₂₂ | | K | MAG ¹ (dB) |
|--------------------|-----------------|------|-----------------|-----|-----------------|-----|-----------------|------|------|--------------------------|
| | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG | | |
| 100 | 0.764 | -28 | 17.806 | 156 | 0.002 | 53 | 0.944 | -12 | 0.91 | 39.5 |
| 200 | 0.675 | -55 | 15.233 | 138 | 0.008 | 70 | 0.855 | -19 | 0.54 | 32.8 |
| 300 | 0.569 | -76 | 12.659 | 126 | 0.018 | 61 | 0.734 | -22 | 0.69 | 28.5 |
| 400 | 0.481 | -94 | 10.620 | 116 | 0.025 | 59 | 0.698 | -25 | 0.74 | 26.3 |
| 500 | 0.432 | -110 | 8.886 | 107 | 0.035 | 59 | 0.602 | -24 | 0.86 | 24.0 |
| 600 | 0.398 | -120 | 7.696 | 102 | 0.043 | 58 | 0.589 | -24 | 0.86 | 22.5 |
| 700 | 0.374 | -133 | 6.888 | 97 | 0.046 | 59 | 0.530 | -26 | 0.99 | 21.8 |
| 800 | 0.354 | -141 | 6.073 | 93 | 0.056 | 59 | 0.522 | -25 | 0.97 | 20.4 |
| 900 | 0.339 | -152 | 5.422 | 88 | 0.055 | 60 | 0.493 | -28 | 1.13 | 17.7 |
| 1000 | 0.332 | -159 | 4.963 | 85 | 0.066 | 61 | 0.493 | -25 | 1.05 | 17.4 |
| 1100 | 0.333 | -166 | 4.576 | 81 | 0.069 | 62 | 0.488 | -28 | 1.08 | 16.5 |
| 1200 | 0.343 | -174 | 4.264 | 78 | 0.076 | 62 | 0.457 | -27 | 1.09 | 15.7 |
| 1300 | 0.332 | 180 | 3.912 | 76 | 0.080 | 63 | 0.467 | -29 | 1.12 | 14.8 |
| 1400 | 0.343 | 173 | 3.656 | 73 | 0.089 | 63 | 0.449 | -29 | 1.09 | 14.3 |
| 1500 | 0.348 | 171 | 3.433 | 71 | 0.098 | 66 | 0.447 | -29 | 1.06 | 13.9 |
| 2000 | 0.414 | 150 | 2.656 | 56 | 0.129 | 60 | 0.388 | -40 | 1.04 | 11.9 |
| 3000 | 0.502 | 126 | 1.829 | 38 | 0.192 | 60 | 0.323 | -63 | 1.00 | 9.8 |
| 4000 | 0.595 | 110 | 1.426 | 17 | 0.256 | 50 | 0.302 | -95 | 0.88 | 7.5 |
| 5000 | 0.650 | 97 | 1.119 | 1 | 0.317 | 44 | 0.343 | -126 | 0.83 | 5.5 |

Note:

1. Gain Calculations:

$$MAG = \frac{|S_{21}|}{|S_{12}|} (K \pm \sqrt{K^2 - 1})$$

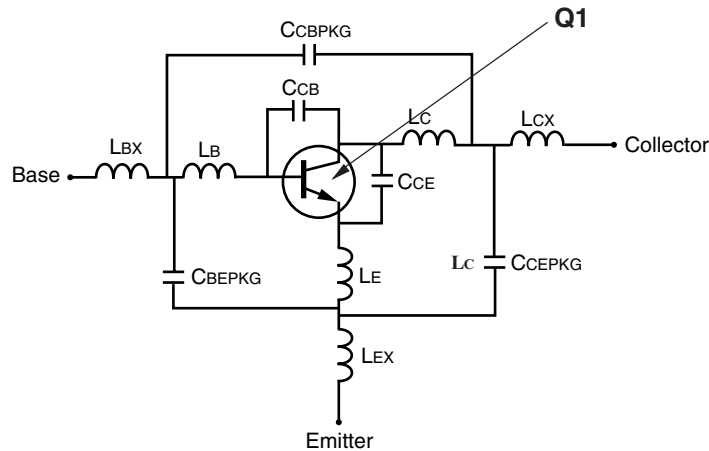
When $K \leq 1$, MAG is undefined and MSG values are used. $MSG = \frac{|S_{21}|}{|S_{12}|}$, $K = \frac{1 + |\Delta|^2 - |S_{11}|^2 - |S_{22}|^2}{2 |S_{12}| |S_{21}|}$, $\Delta = S_{11} S_{22} - S_{21} S_{12}$

MAG = Maximum Available Gain

MSG = Maximum Stable Gain

NE68118 NONLINEAR MODEL

SCHEMATIC



BJT NONLINEAR MODEL PARAMETERS(1)

| Parameters | Q1 | Parameters | Q1 |
|------------|----------|------------|--------|
| IS | 2.7e-16 | MJC | 0.56 |
| BF | 185 | XCJC | 0 |
| NF | 1.02 | CJS | 0 |
| VAF | 15 | VJS | 0.75 |
| IKF | 0.055 | MJS | 0 |
| ISE | 1.77e-11 | FC | 0.5 |
| NE | 2.1 | TF | 14e-12 |
| BR | 1 | XTF | 3 |
| NR | 1 | VTF | 25 |
| VAR | Infinity | ITF | 0.1 |
| IKR | Infinity | PTF | 0 |
| ISC | 0 | TR | 0.3e-9 |
| NC | 2 | EG | 1.11 |
| RE | 0.6 | XTB | 0 |
| RB | 12 | XTI | 3 |
| RBM | 3.7 | KF | 0 |
| IRB | 1.2e-5 | AF | 1 |
| RC | 8 | | |
| CJE | 1.2e-12 | | |
| VJE | 0.77 | | |
| MJE | 0.5 | | |
| CJC | 0.8e-12 | | |
| VJC | 0.27 | | |

(1) Gummel-Poon Model

UNITS

| Parameter | Units |
|-------------|---------|
| time | seconds |
| capacitance | farads |
| inductance | henries |
| resistance | ohms |
| voltage | volts |
| current | amps |

ADDITIONAL PARAMETERS

| Parameters | 68118 |
|------------|----------|
| CCE | 0.01e-12 |
| LC | 1.54e-9 |
| LE | 0.83e-9 |
| CCEPKG | 0.51e-12 |
| CBEPKG | 0.25e-12 |
| LBX | 0.18e-9 |
| LCX | 0.8e-9 |
| LEX | 0.09e-9 |

MODEL RANGE

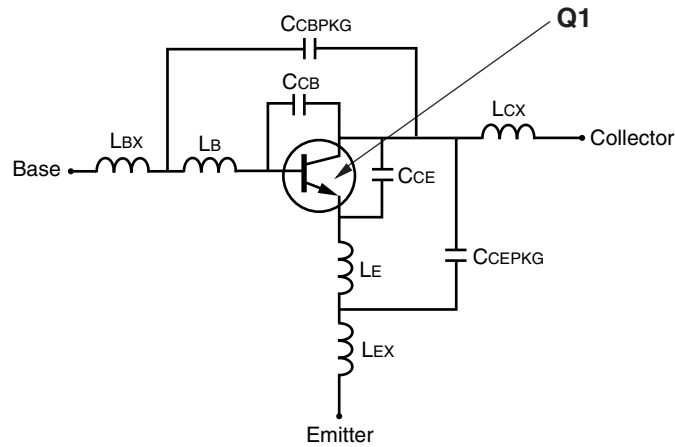
Frequency: 0.05 to 5.0 GHz
 Bias: VCE = 2.5 V to 8.0 V, IC = 3 mA to 10 mA
 Date: 5/29/96

Note:

1. This nonlinear model utilized the latest data available. See our Design Parameter Library at www.cel.com for this data.

NE68119 NONLINEAR MODEL

SCHEMATIC



BJT NONLINEAR MODEL PARAMETERS⁽¹⁾

| Parameters | Q1 | Parameters | Q1 |
|------------|----------|------------|----------|
| IS | 2.7e-16 | MJC | 0.56 |
| BF | 185.0 | XCJC | 0 |
| NF | 1.02 | CJS | 0 |
| VAF | 15.0 | VJS | 0.75 |
| IKF | 0.055 | MJS | 0 |
| ISE | 1.77e-11 | FC | 0.5 |
| NE | 2.1 | TF | 14.0e-12 |
| BR | 1 | XTF | 3 |
| NR | 1 | VTF | 25 |
| VAR | Infinity | ITF | 0.1 |
| IKR | Infinity | PTF | 0 |
| ISC | 0 | TR | 0.3e-9 |
| NC | 2 | EG | 1.11 |
| RE | 0.6 | XTB | 0 |
| RB | 12 | XTI | 3 |
| RBM | 3.7 | KF | 0 |
| IRB | 1.2e-5 | AF | 1 |
| RC | 8 | | |
| CJE | 1.2e-12 | | |
| VJE | 0.77 | | |
| MJE | 0.5 | | |
| CJC | 0.8e-12 | | |
| VJC | 0.27 | | |

(1) Gummel-Poon Model

UNITS

| Parameter | Units |
|-------------|---------|
| time | seconds |
| capacitance | farads |
| inductance | henries |
| resistance | ohms |
| voltage | volts |
| current | amps |

ADDITIONAL PARAMETERS

| Parameters | 68119 |
|------------|----------|
| CCB | 0.07e-12 |
| CCE | 0.01e-12 |
| LB | 1.13e-9 |
| LE | 0.85e-9 |
| CCEPKG | 0.18e-12 |
| CCEPKG | 0.21e-12 |
| LBX | 0.19e-9 |
| LCX | 0.19e-9 |
| LEX | 0.19e-9 |

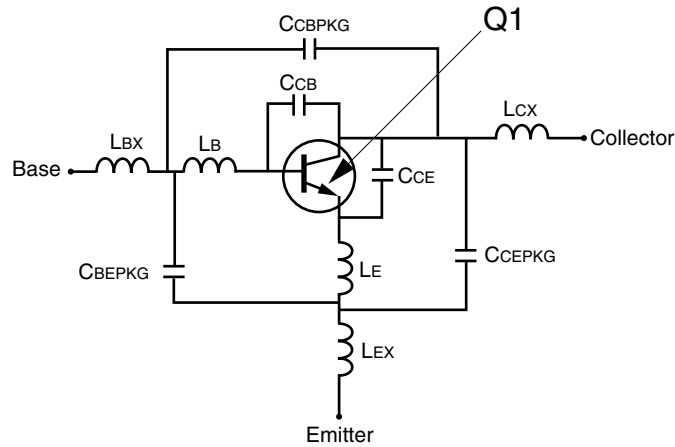
MODEL RANGE

Frequency: 0.05 to 3.0 GHz

Bias: VCE = 2.5 V to 8.0 V, IC = 0.3 mA to 10 mA

NE68130 NONLINEAR MODEL

SCHEMATIC



BJT NONLINEAR MODEL PARAMETERS ⁽¹⁾

| Parameters | Q1 | Parameters | Q1 |
|------------|----------|------------|--------|
| IS | 2.7e-16 | MJC | 0.56 |
| BF | 185 | XCJC | 0 |
| NF | 1.02 | CJS | 0 |
| VAF | 15 | VJS | 0.75 |
| IKF | 0.055 | MJS | 0 |
| ISE | 1.77e-11 | FC | 0.5 |
| NE | 2.1 | TF | 14e-12 |
| BR | 1 | XTF | 3 |
| NR | 1 | VTF | 25 |
| VAR | Infinity | ITF | 0.1 |
| IKR | Infinity | PTF | 0 |
| ISC | 0 | TR | 0.3e-9 |
| NC | 2 | EG | 1.11 |
| RE | 0.6 | XTB | 0 |
| RB | 12 | XTI | 3 |
| RBM | 3.7 | KF | 0 |
| IRB | 1.2e-5 | AF | 1 |
| RC | 8 | | |
| CJE | 1.2e-12 | | |
| VJE | 0.77 | | |
| MJE | 0.5 | | |
| CJC | 0.8e-12 | | |
| VJC | 0.27 | | |

(1) Gummel-Poon Model

UNITS

| Parameter | Units |
|-------------|---------|
| time | seconds |
| capacitance | farads |
| inductance | henries |
| resistance | ohms |
| voltage | volts |
| current | amps |

ADDITIONAL PARAMETERS

| Parameters | 68130 |
|------------|----------|
| CCB | 0.07e-12 |
| CCE | 0.01e-12 |
| LB | 0.52e-9 |
| LE | 1.18e-9 |
| CCBPKG | 0.12e-12 |
| CCEPKG | 0.16e-12 |
| CBEPKG | 0.04e-12 |
| LBX | 0.2e-9 |
| LCX | 0.8e-9 |
| LEX | 0.2e-9 |

MODEL RANGE

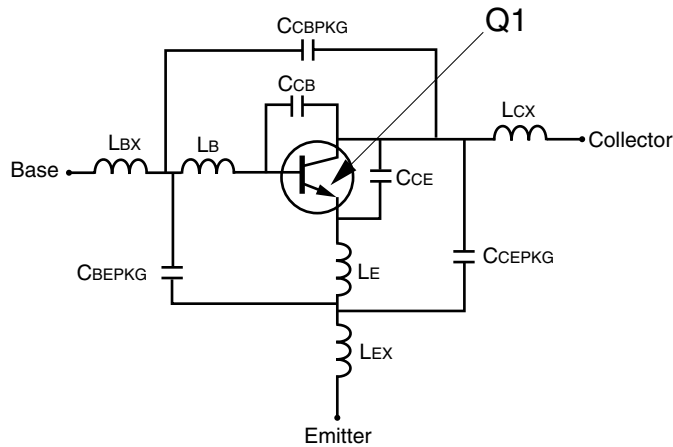
Frequency: 0.05 to 3.0 GHz
 Bias: $V_{CE} = 2.5 \text{ V to } 8 \text{ V}$, $I_c = 0.3 \text{ mA to } 10 \text{ mA}$
 Date: 10/11/96

Note:

This nonlinear model utilized the latest data available. See our Design Parameter Library at www.cel.com for this data.

NE68133 NONLINEAR MODEL

SCHEMATIC



BJT NONLINEAR MODEL PARAMETERS (1)

| Parameters | Q1 | Parameters | Q1 |
|------------|----------|------------|--------|
| IS | 2.7e-16 | MJC | 0.56 |
| BF | 185 | XCJC | 0 |
| NF | 1.02 | CJS | 0 |
| VAF | 15 | VJS | 0.75 |
| IKF | 0.055 | MJS | 0 |
| ISE | 1.77e-11 | FC | 0.5 |
| NE | 2.1 | TF | 14e-12 |
| BR | 1 | XTF | 3 |
| NR | 1 | VTF | 25 |
| VAR | Infinity | ITF | 0.1 |
| IKR | Infinity | PTF | 0 |
| ISC | 0 | TR | 0.3e-9 |
| NC | 2 | EG | 1.11 |
| RE | 0.6 | XTB | 0 |
| RB | 12 | XTI | 3 |
| RBM | 3.7 | KF | 0 |
| IRB | 1.2e-5 | AF | 1 |
| RC | 8 | | |
| CJE | 1.2e-12 | | |
| VJE | 0.77 | | |
| MJE | 0.5 | | |
| CJC | 0.8e-12 | | |
| VJC | 0.27 | | |

(1) Gummel-Poon Model

UNITS

| Parameter | Units |
|-------------|---------|
| time | seconds |
| capacitance | farads |
| inductance | henries |
| resistance | ohms |
| voltage | volts |
| current | amps |

ADDITIONAL PARAMETERS

| Parameters | 68133 |
|------------|----------|
| CCB | 0.07e-12 |
| CCE | 0.01e-12 |
| LB | 0.9e-9 |
| LE | 1.2e-9 |
| CCBPKG | 0.2e-12 |
| CCEPKG | 0.2e-12 |
| CBEPKG | 0.01e-12 |
| LBX | 0.3e-9 |
| LCX | 0.6e-9 |
| LEX | 0.3e-9 |

MODEL RANGE

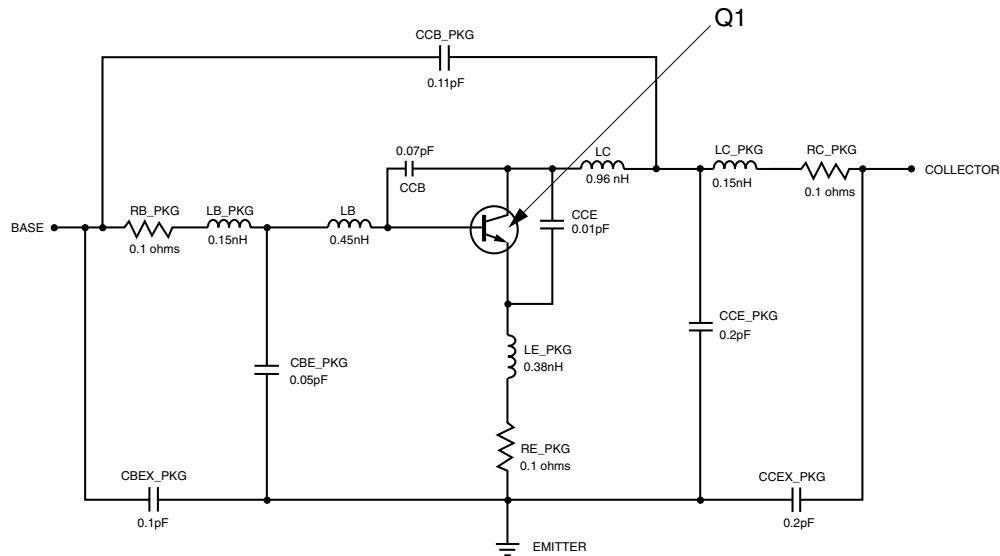
Frequency: 0.1 to 8.0 GHz
 Bias: VCE = 1 V to 8 V, IC = 1 mA to 30 mA
 Date: 7/97

Note:

This nonlinear model utilized the latest data available. See our Design Parameter Library at www.cel.com for this data.

NE68135 NONLINEAR MODEL

SCHEMATIC



BJT NONLINEAR MODEL PARAMETERS (1)

| Parameters | Q1 | Parameters | Q1 |
|------------|----------|------------|--------|
| IS | 2.7e-16 | MJC | 0.56 |
| BF | 185.0 | XCJC | 0 |
| NF | 1.02 | CJS | 0 |
| VAF | 15.0 | VJS | 0.75 |
| IKF | 0.055 | MJS | 0 |
| ISE | 1.77e-11 | FC | 0.5 |
| NE | 2.1 | TF | 14e-12 |
| BR | 1 | XTF | 3 |
| NR | 1 | VTF | 25 |
| VAR | Infinity | ITF | 0.1 |
| IKR | Infinity | PTF | 0 |
| ISC | 0 | TR | 0.3e-9 |
| NC | 2 | EG | 1.11 |
| RE | 0.6 | XTB | 0 |
| RB | 12 | XTI | 3 |
| RBM | 3.7 | KF | 0 |
| IRB | 1.2e-5 | AF | 1 |
| RC | 8 | | |
| CJE | 1.2e-12 | | |
| VJE | 0.77 | | |
| MJE | 0.5 | | |
| CJC | 0.8e-12 | | |
| VJC | 0.27 | | |

UNITS

| Parameter | Units |
|-------------|---------|
| time | seconds |
| capacitance | farads |
| inductance | henries |
| resistance | ohms |
| voltage | volts |
| current | amps |

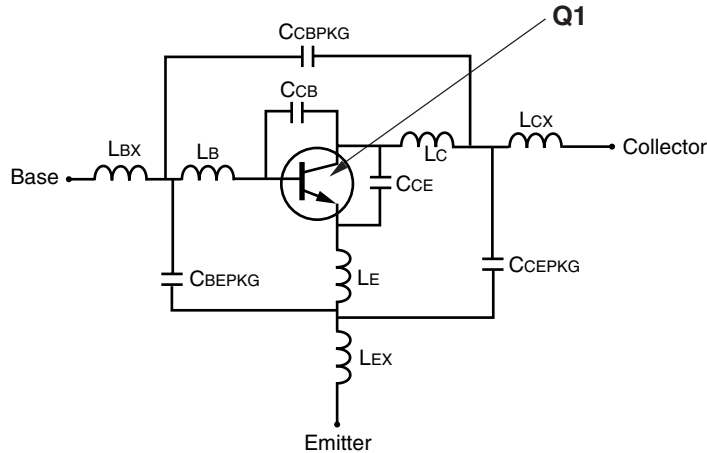
MODEL RANGE

Frequency: 0.05 to 5.0 GHz
 Bias: V_{CE} = 8.0 V, I_c = 7 mA to 30 mA
 Date: 11/1/96

(1) Gummel-Poon Model

NE68139 NONLINEAR MODEL

SCHEMATIC



BJT NONLINEAR MODEL PARAMETERS(1)

| Parameters | Q1 | Parameters | Q1 |
|------------|----------|------------|----------|
| IS | 2.7e-16 | MJC | 0.56 |
| BF | 185.0 | XCJC | 0 |
| NF | 1.02 | CJS | 0 |
| VAF | 15.0 | VJS | 0.750 |
| IKF | 0.055 | MJS | 0 |
| ISE | 1.77e-11 | FC | 0.50 |
| NE | 2.1 | TF | 14.0e-12 |
| BR | 1.0 | XTF | 3.0 |
| NR | 1.0 | VTF | 25.0 |
| VAR | Infinity | ITF | 0.1 |
| IKR | Infinity | PTF | 0 |
| ISC | 0 | TR | 0.3e-9 |
| NC | 2.0 | EG | 1.11 |
| RE | 0.6 | XTB | 0 |
| RB | 12.0 | XTI | 3.0 |
| RBM | 3.7 | KF | 0 |
| IRB | 1.2e-5 | AF | 1.0 |
| RC | 8.0 | | |
| CJE | 1.2e-12 | | |
| VJE | 0.77 | | |
| MJE | 0.50 | | |
| CJC | 0.8e-12 | | |
| VJC | 0.27 | | |

(1) Gummel-Poon Model

UNITS

| Parameter | Units |
|-------------|---------|
| time | seconds |
| capacitance | farads |
| inductance | henries |
| resistance | ohms |
| voltage | volts |
| current | amps |

ADDITIONAL PARAMETERS

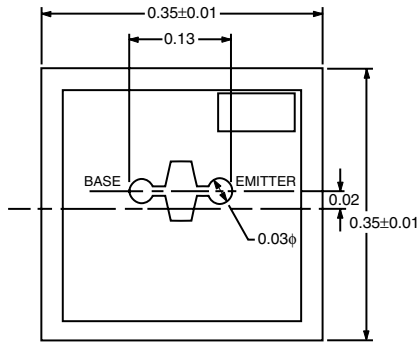
| Parameters | 68139 |
|------------|-----------|
| CCB | 0.07e-12 |
| CCE | 0.01e-12 |
| LB | 0.88e-9 |
| LC | 0.79e-9 |
| LE | 0.7e-9 |
| CCBPKG | 0.165e-12 |
| CCEPKG | 0.165e-12 |
| CBEPKG | 0.01e-12 |
| LBX | 0.39e-9 |
| LCX | 0.39e-9 |
| LEX | 0.2e-9 |

MODEL RANGE

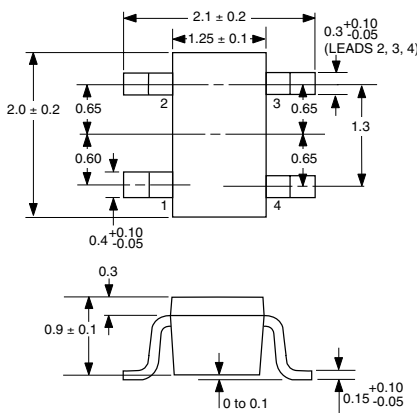
Frequency: 0.1 to 3.0 GHz
 Bias: VCE = 2.5 V to 8.0 V, IC = 0.3 mA to 7 mA
 Date: 6/17/96

OUTLINE DIMENSIONS (Units in mm)

NE68100 (CHIP)
(Chip Thickness: 160 μm)

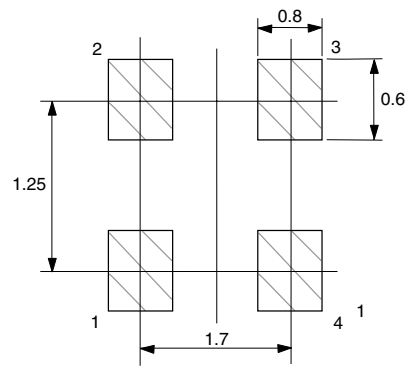


PACKAGE OUTLINE 18

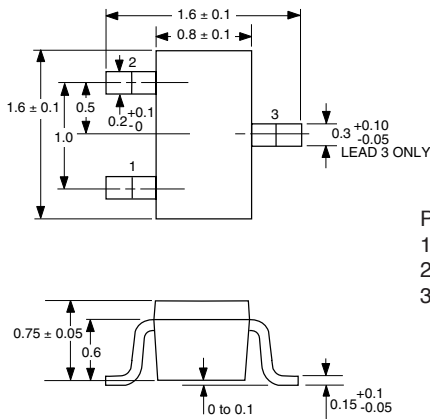


- PIN CONNECTIONS**
1. Collector
 2. Emitter
 3. Base
 4. Emitter

PACKAGE OUTLINE 18
RECOMMENDED P.C.B. LAYOUT

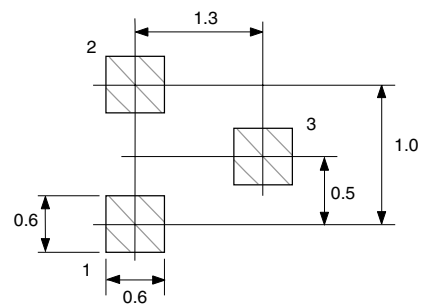


PACKAGE OUTLINE 19

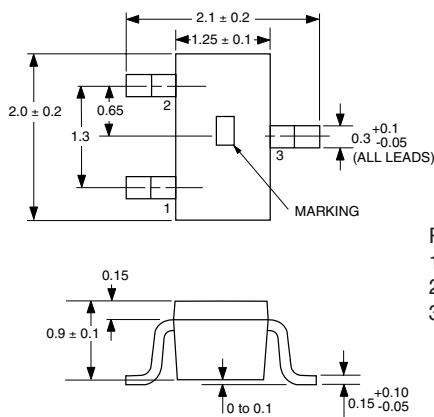


- PIN CONNECTIONS**
1. Emitter
 2. Base
 3. Collector

PACKAGE OUTLINE 19
RECOMMENDED P.C.B. LAYOUT

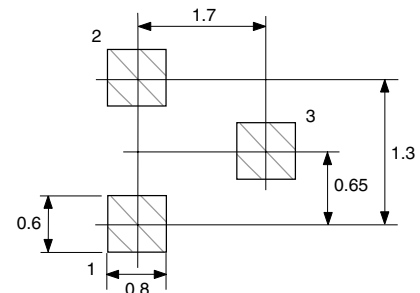


PACKAGE OUTLINE 30



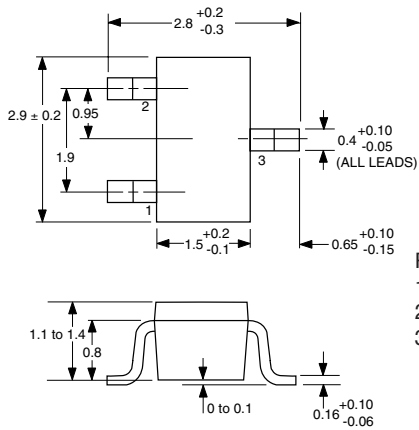
- PIN CONNECTIONS**
1. Emitter
 2. Base
 3. Collector

PACKAGE OUTLINE 30
RECOMMENDED P.C.B. LAYOUT



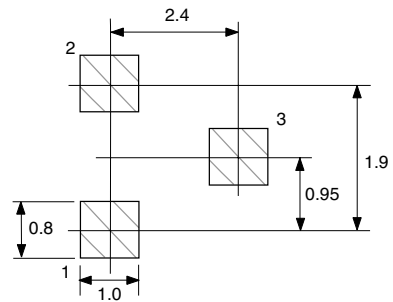
OUTLINE DIMENSIONS (Units in mm)

PACKAGE OUTLINE 33
(SOT-23)

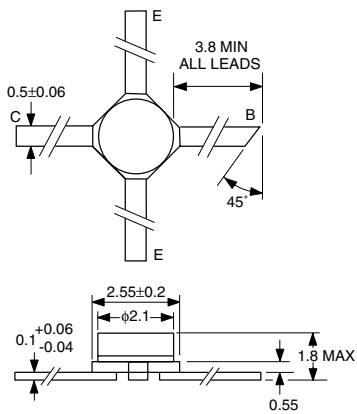


PIN CONNECTIONS
1. Emitter
2. Base
3. Collector

PACKAGE OUTLINE 33
RECOMMENDED P.C.B. LAYOUT

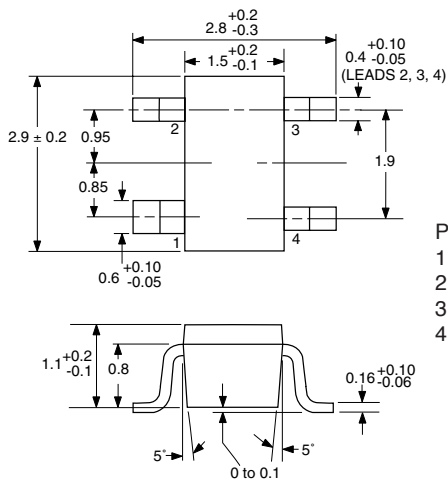


PACKAGE OUTLINE 35
(MICRO-X)



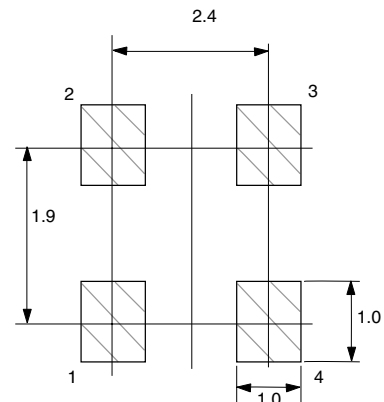
PIN CONNECTIONS
1. Collector
2. Emitter
3. Base
4. Emitter

PACKAGE OUTLINE 39



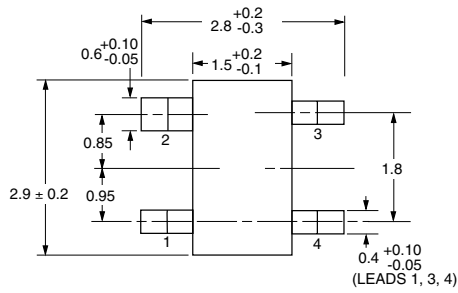
PIN CONNECTIONS
1. Collector
2. Emitter
3. Base
4. Emitter

PACKAGE OUTLINE 39
RECOMMENDED P.C.B. LAYOUT



OUTLINE DIMENSIONS (Units in mm)

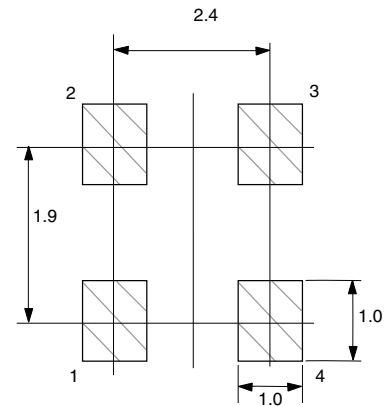
PACKAGE OUTLINE 39R



PIN CONNECTIONS

- 1. Emitter
- 2. Collector
- 3. Emitter
- 4. Base

**PACKAGE OUTLINE 39R
RECOMMENDED P.C.B. LAYOUT**



ORDERING INFORMATION (Solder Contains Lead)

| PART NUMBER | QUANTITY | PACKAGING |
|-------------|----------|-------------|
| NE68100 | 100 | Waffle Pack |
| NE68118-T1 | 3000 | Tape & Reel |
| NE68119-T1 | 3000 | Tape & Reel |
| NE68130-T1 | 3000 | Tape & Reel |
| NE68133-T1B | 3000 | Tape & Reel |
| NE68135 | 1 | ESD Bag |
| NE68139-T1 | 3000 | Tape & Reel |
| NE68139R-T1 | 3000 | Tape & Reel |

ORDERING INFORMATION (Pb-Free)

| PART NUMBER | QUANTITY | PACKAGING |
|---------------|----------|-------------|
| NE68100 | 100 | Waffle Pack |
| NE68118-T1-A | 3000 | Tape & Reel |
| NE68119-T1-A | 3000 | Tape & Reel |
| NE68130-T1-A | 3000 | Tape & Reel |
| NE68133-T1B-A | 3000 | Tape & Reel |
| NE68135 | 1 | ESD Bag |
| NE68139-T1-A | 3000 | Tape & Reel |
| NE68139R-T1 | 3000 | Tape & Reel |

Life Support Applications

These NEC products are not intended for use in life support devices, appliances, or systems where the malfunction of these products can reasonably be expected to result in personal injury. The customers of CEL using or selling these products for use in such applications do so at their own risk and agree to fully indemnify CEL for all damages resulting from such improper use or sale.

Subject: Compliance with EU Directives

CEL certifies, to its knowledge, that semiconductor and laser products detailed below are compliant with the requirements of European Union (EU) Directive 2002/95/EC Restriction on Use of Hazardous Substances in electrical and electronic equipment (RoHS) and the requirements of EU Directive 2003/11/EC Restriction on Penta and Octa BDE.

CEL Pb-free products have the same base part number with a suffix added. The suffix –A indicates that the device is Pb-free. The –AZ suffix is used to designate devices containing Pb which are exempted from the requirement of RoHS directive (*). In all cases the devices have Pb-free terminals. All devices with these suffixes meet the requirements of the RoHS directive.

This status is based on CEL’s understanding of the EU Directives and knowledge of the materials that go into its products as of the date of disclosure of this information.

| Restricted Substance per RoHS | Concentration Limit per RoHS (values are not yet fixed) | Concentration contained in CEL devices | |
|-------------------------------|---|--|-----|
| | | -A | -AZ |
| Lead (Pb) | < 1000 PPM | Not Detected | (*) |
| Mercury | < 1000 PPM | Not Detected | |
| Cadmium | < 100 PPM | Not Detected | |
| Hexavalent Chromium | < 1000 PPM | Not Detected | |
| PBB | < 1000 PPM | Not Detected | |
| PBDE | < 1000 PPM | Not Detected | |

If you should have any additional questions regarding our devices and compliance to environmental standards, please do not hesitate to contact your local representative.

Important Information and Disclaimer: Information provided by CEL on its website or in other communications concerning the substance content of its products represents knowledge and belief as of the date that it is provided. CEL bases its knowledge and belief on information provided by third parties and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. CEL has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. CEL and CEL suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall CEL’s liability arising out of such information exceed the total purchase price of the CEL part(s) at issue sold by CEL to customer on an annual basis.

See CEL Terms and Conditions for additional clarification of warranties and liability.