

# DATA SHEET

# NEC

## NPN SILICON RF TRANSISTOR 2SC5618

### NPN SILICON RF TRANSISTOR FOR HIGH-FREQUENCY LOW NOISE 3-PIN LEAD-LESS MINIMOLD

#### FEATURES

- NF = 1.5 dB TYP. @  $V_{CE} = 1\text{ V}$ ,  $I_C = 3\text{ mA}$ ,  $f = 2\text{ GHz}$
- NF = 1.4 dB TYP. @  $V_{CE} = 2\text{ V}$ ,  $I_C = 3\text{ mA}$ ,  $f = 2\text{ GHz}$
- 3-pin lead-less minimold package

#### ORDERING INFORMATION

| Part Number | Quantity          | Supplying Form                                       |
|-------------|-------------------|------------------------------------------------------|
| 2SC5618     | 50 pcs (Non reel) | • 8 mm wide embossed taping                          |
| 2SC5618-T3  | 10 kpcs/reel      | • Pin 2 (Base) face the perforation side of the tape |

**Remark** To order evaluation samples, contact your nearby sales office.  
The unit sample quantity is 50 pcs.

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

| Parameter                    | Symbol                        | Ratings     | Unit             |
|------------------------------|-------------------------------|-------------|------------------|
| Collector to Base Voltage    | $V_{CBO}$                     | 5.0         | V                |
| Collector to Emitter Voltage | $V_{CEO}$                     | 3.0         | V                |
| Emitter to Base Voltage      | $V_{EBO}$                     | 2.0         | V                |
| Collector Current            | $I_C$                         | 30          | mA               |
| Total Power Dissipation      | $P_{tot}$ <small>Note</small> | 90          | mW               |
| Junction Temperature         | $T_j$                         | 150         | $^\circ\text{C}$ |
| Storage Temperature          | $T_{stg}$                     | -65 to +150 | $^\circ\text{C}$ |

**Note** Mounted on  $1.08\text{ cm}^2 \times 1.0\text{ mm}$  (t) glass epoxy PCB

Because this product uses high-frequency technology, avoid excessive static electricity, etc.

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Not all devices/types available in every country. Please check with local NEC Compound Semiconductor Devices representative for availability and additional information.

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

| Parameter                    | Symbol                            | Test Conditions                                                                               | MIN. | TYP. | MAX. | Unit |
|------------------------------|-----------------------------------|-----------------------------------------------------------------------------------------------|------|------|------|------|
| DC Characteristics           |                                   |                                                                                               |      |      |      |      |
| Collector Cut-off Current    | I <sub>CBO</sub>                  | V <sub>CB</sub> = 5 V, I <sub>E</sub> = 0 mA                                                  | –    | –    | 100  | nA   |
| Emitter Cut-off Current      | I <sub>EBO</sub>                  | V <sub>EB</sub> = 1 V, I <sub>C</sub> = 0 mA                                                  | –    | –    | 100  | nA   |
| DC Current Gain              | h <sub>FE</sub> <sup>Note 1</sup> | V <sub>CE</sub> = 2 V, I <sub>C</sub> = 20 mA                                                 | 70   | –    | 130  | –    |
| RF Characteristics           |                                   |                                                                                               |      |      |      |      |
| Gain Bandwidth Product (1)   | f <sub>T</sub>                    | V <sub>CE</sub> = 2 V, I <sub>C</sub> = 20 mA, f = 2 GHz                                      | 9.0  | 14.0 | –    | GHz  |
| Gain Bandwidth Product (2)   | f <sub>T</sub>                    | V <sub>CE</sub> = 1 V, I <sub>C</sub> = 10 mA, f = 2 GHz                                      | 7.0  | 12.0 | –    | GHz  |
| Insertion Power Gain (1)     | S <sub>21e</sub>   <sup>2</sup>   | V <sub>CE</sub> = 2 V, I <sub>C</sub> = 20 mA, f = 2 GHz                                      | 8.5  | 10.0 | –    | dB   |
| Insertion Power Gain (2)     | S <sub>21e</sub>   <sup>2</sup>   | V <sub>CE</sub> = 1 V, I <sub>C</sub> = 10 mA, f = 2 GHz                                      | 6.0  | 9.0  | –    | dB   |
| Noise Figure (1)             | NF                                | V <sub>CE</sub> = 2 V, I <sub>C</sub> = 3 mA, f = 2 GHz,<br>Z <sub>S</sub> = Z <sub>opt</sub> | –    | 1.4  | 2.0  | dB   |
| Noise Figure (2)             | NF                                | V <sub>CE</sub> = 1 V, I <sub>C</sub> = 3 mA, f = 2 GHz,<br>Z <sub>S</sub> = Z <sub>opt</sub> | –    | 1.5  | 2.0  | dB   |
| Reverse Transfer Capacitance | C <sub>re</sub> <sup>Note 2</sup> | V <sub>CB</sub> = 2 V, I <sub>E</sub> = 0 mA, f = 1 MHz                                       | –    | 0.4  | 0.8  | pF   |

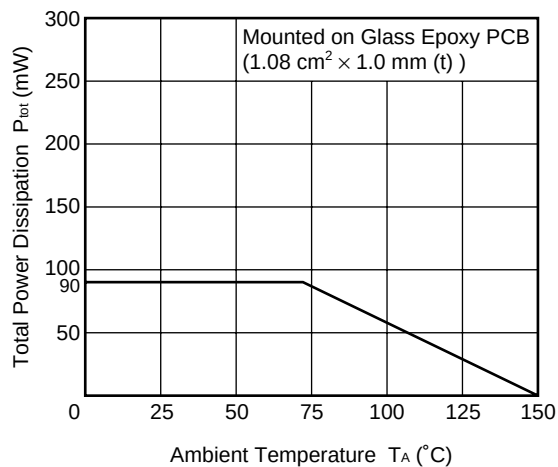
- Notes** 1. Pulse measurement: PW ≤ 350 μs, Duty Cycle ≤ 2%  
2. Collector to base capacitance when the emitter grounded

**h<sub>FE</sub> CLASSIFICATION**

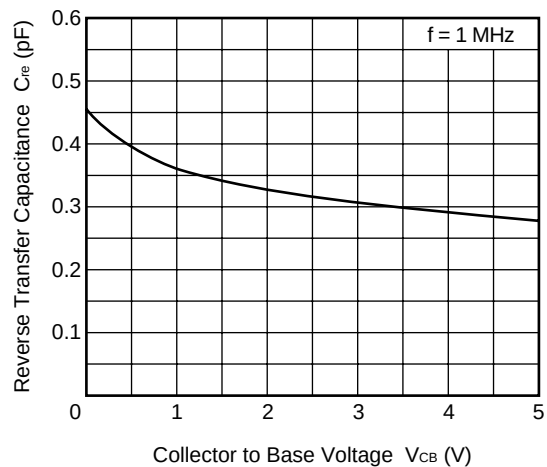
| Rank                  | EB        | FB        |
|-----------------------|-----------|-----------|
| Marking               | W1        | W2        |
| h <sub>FE</sub> Value | 70 to 100 | 90 to 130 |

★ TYPICAL CHARACTERISTICS (Unless otherwise specified,  $T_A = +25^\circ\text{C}$ )

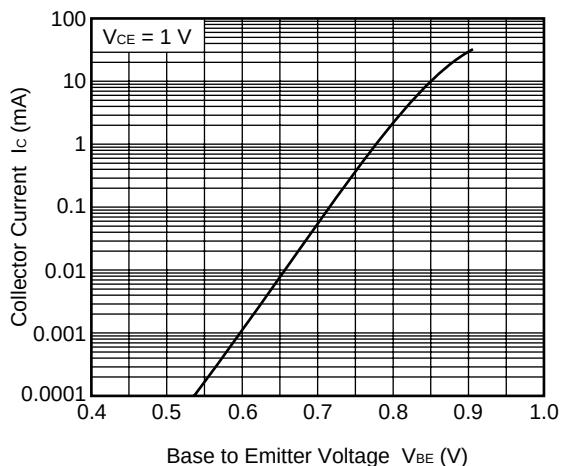
TOTAL POWER DISSIPATION  
vs. AMBIENT TEMPERATURE



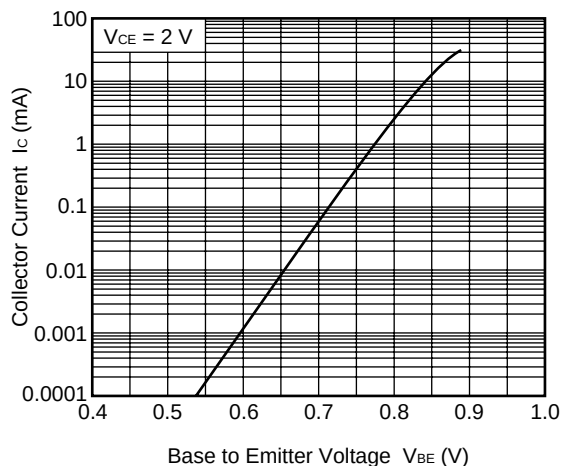
REVERSE TRANSFER CAPACITANCE  
vs. COLLECTOR TO BASE VOLTAGE



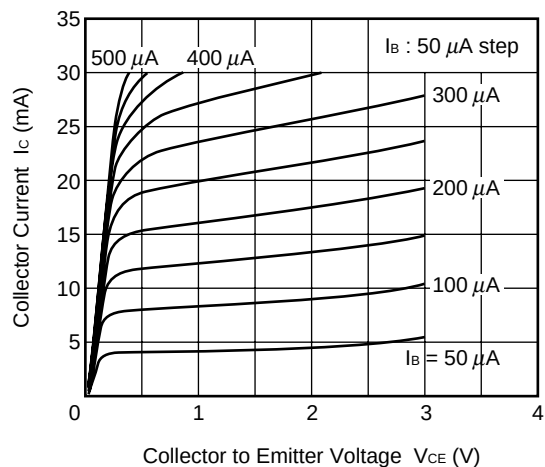
COLLECTOR CURRENT vs.  
BASE TO EMITTER VOLTAGE

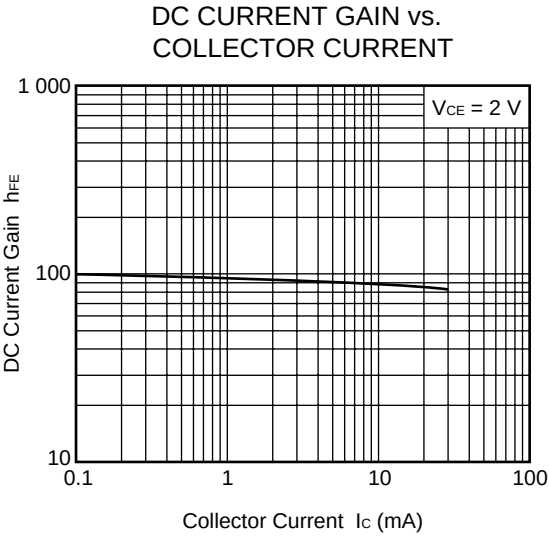
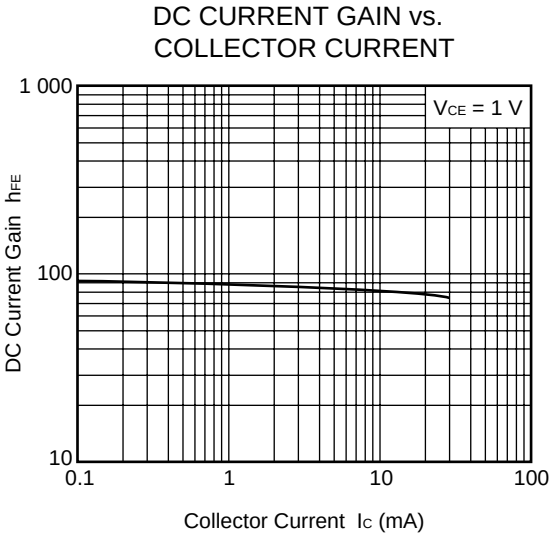


COLLECTOR CURRENT vs.  
BASE TO EMITTER VOLTAGE

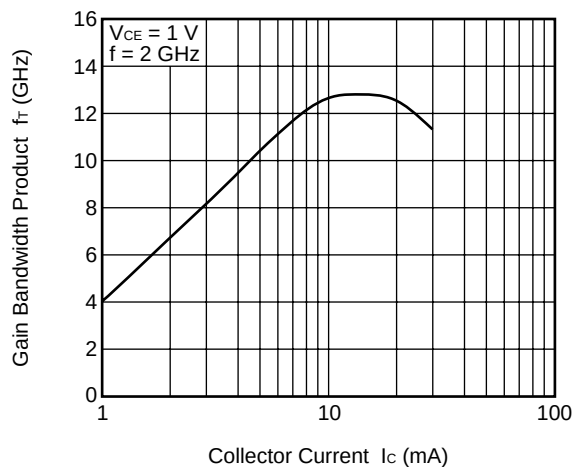


COLLECTOR CURRENT vs.  
COLLECTOR TO EMITTER VOLTAGE

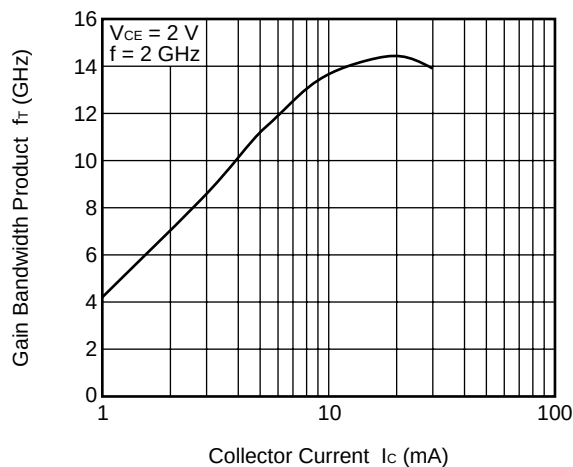




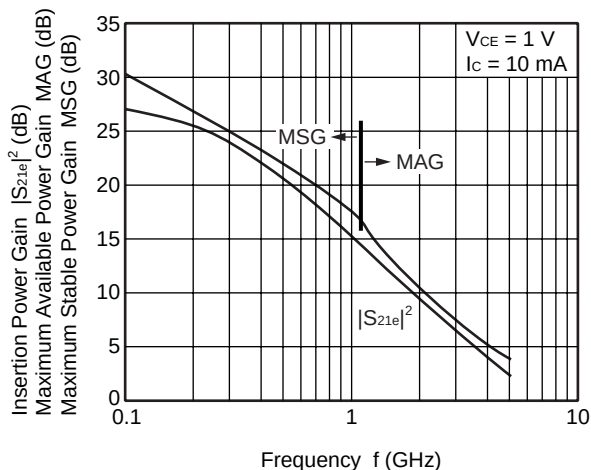
GAIN BANDWIDTH PRODUCT  
vs. COLLECTOR CURRENT



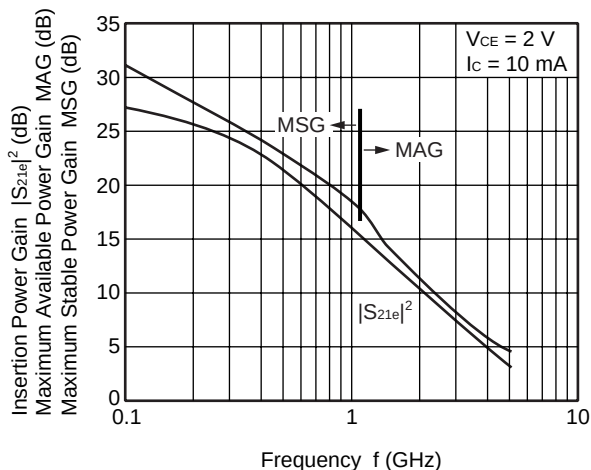
GAIN BANDWIDTH PRODUCT  
vs. COLLECTOR CURRENT



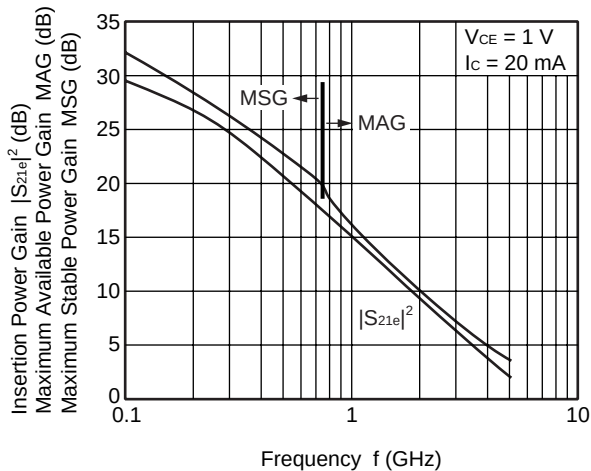
INSERTION POWER GAIN,  
MAG, MSG vs. FREQUENCY



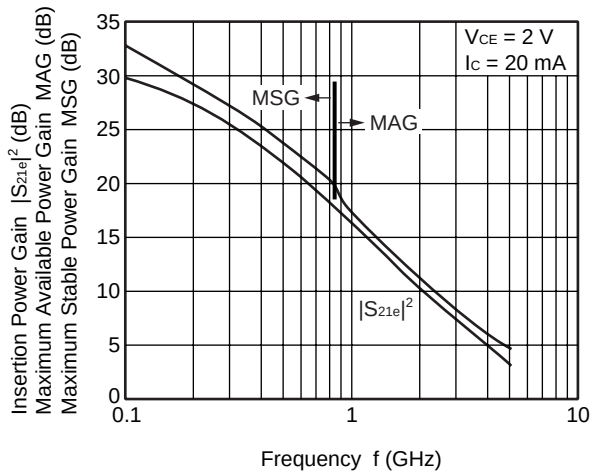
INSERTION POWER GAIN,  
MAG, MSG vs. FREQUENCY



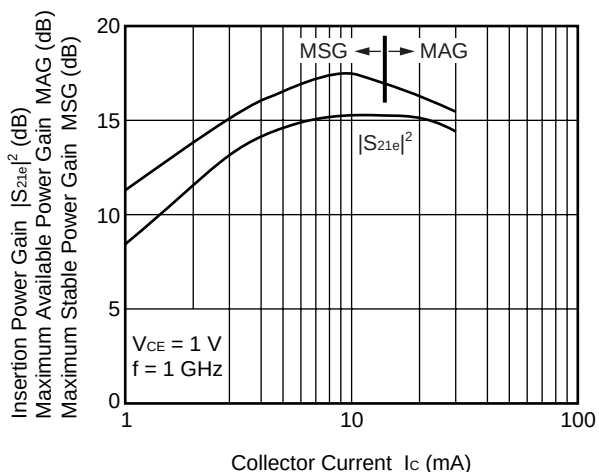
INSERTION POWER GAIN,  
MAG, MSG vs. FREQUENCY



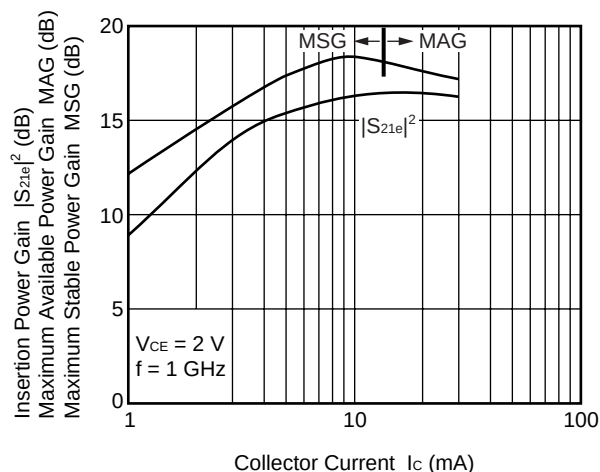
INSERTION POWER GAIN,  
MAG, MSG vs. FREQUENCY



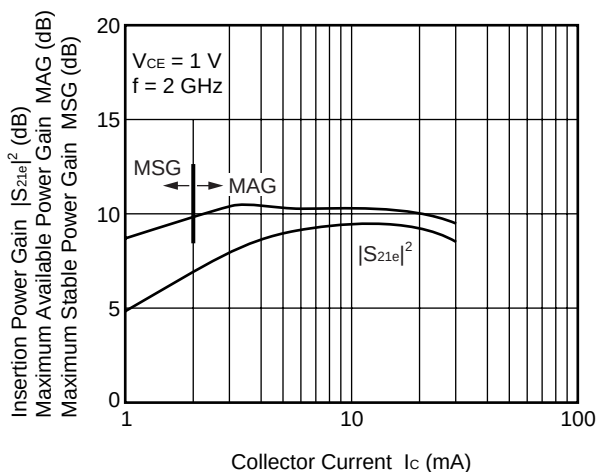
INSERTION POWER GAIN, MAG, MSG  
vs. COLLECTOR CURRENT



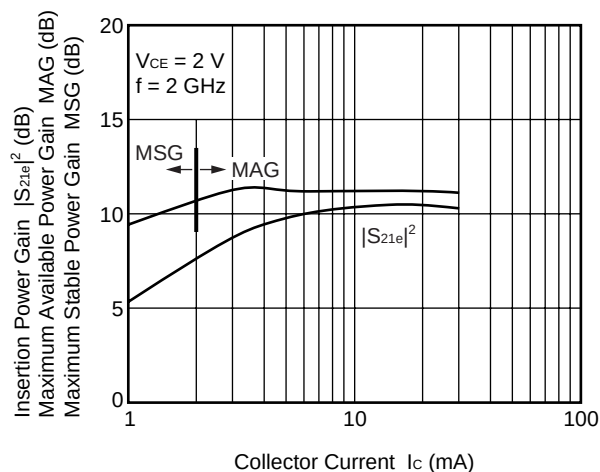
INSERTION POWER GAIN, MAG, MSG  
vs. COLLECTOR CURRENT



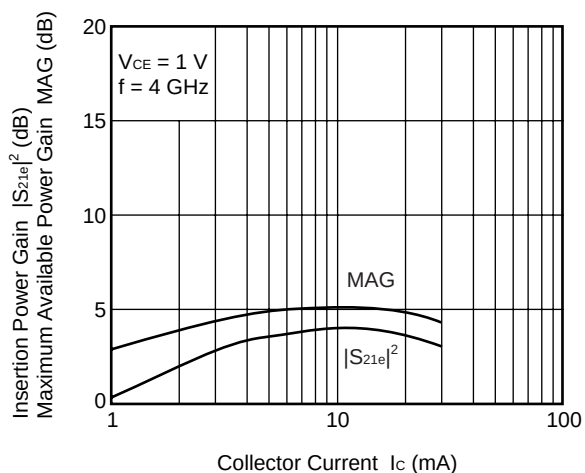
INSERTION POWER GAIN, MAG, MSG  
vs. COLLECTOR CURRENT



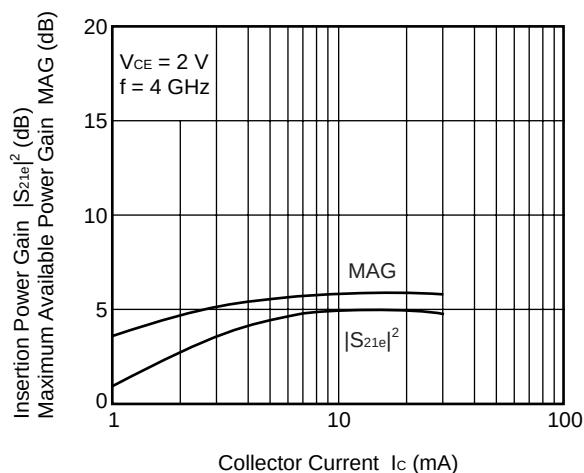
INSERTION POWER GAIN, MAG, MSG  
vs. COLLECTOR CURRENT



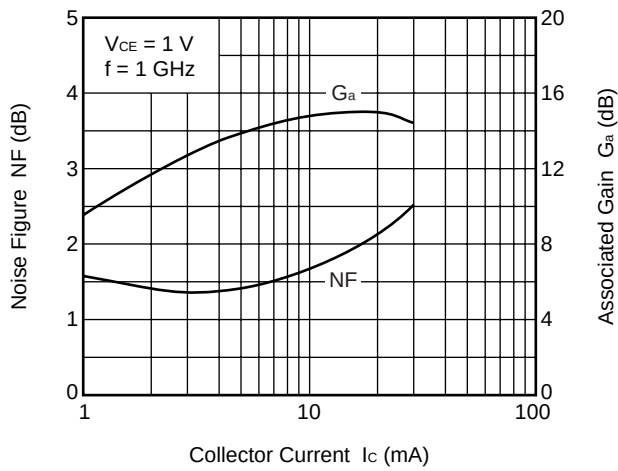
INSERTION POWER GAIN, MAG  
vs. COLLECTOR CURRENT



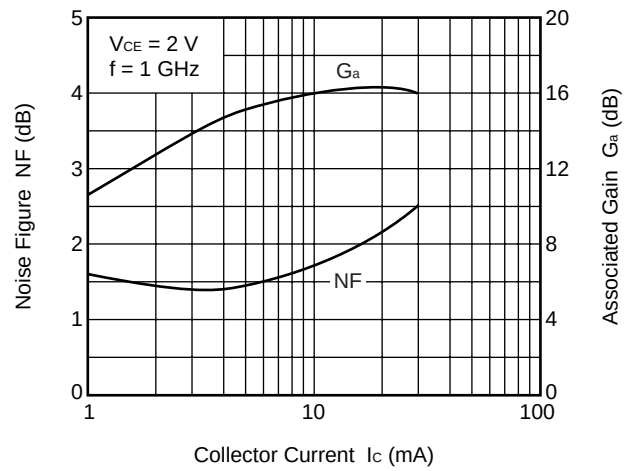
INSERTION POWER GAIN, MAG  
vs. COLLECTOR CURRENT



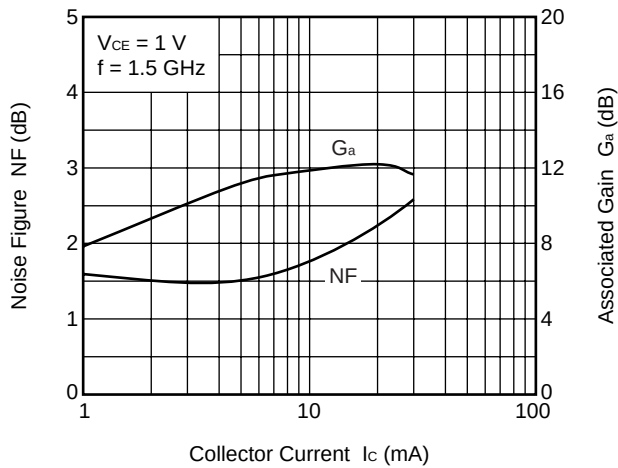
NOISE FIGURE, ASSOCIATED GAIN  
vs. COLLECTOR CURRENT



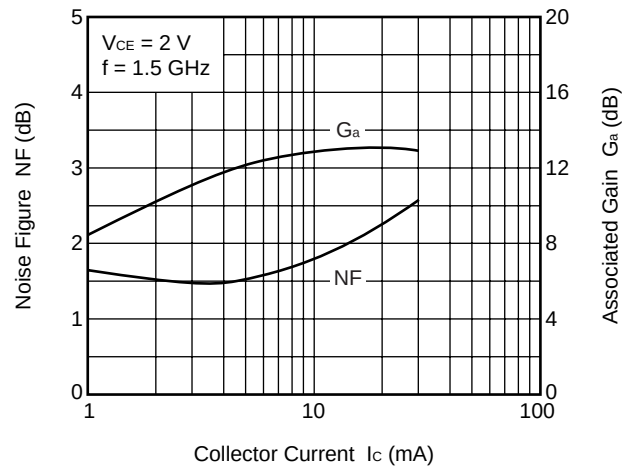
NOISE FIGURE, ASSOCIATED GAIN  
vs. COLLECTOR CURRENT



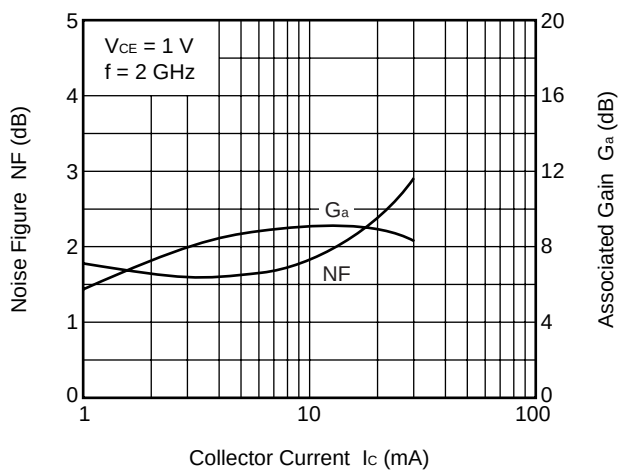
NOISE FIGURE, ASSOCIATED GAIN  
vs. COLLECTOR CURRENT



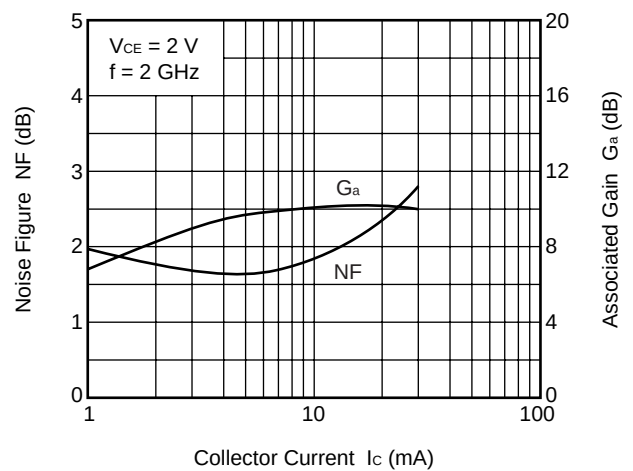
NOISE FIGURE, ASSOCIATED GAIN  
vs. COLLECTOR CURRENT



NOISE FIGURE, ASSOCIATED GAIN  
vs. COLLECTOR CURRENT



NOISE FIGURE, ASSOCIATED GAIN  
vs. COLLECTOR CURRENT



**Remark** The graphs indicate nominal characteristics.

S-PARAMETERS

$V_{CE} = 1\text{ V}$ ,  $I_C = 1\text{ mA}$ ,  $Z_0 = 50\ \Omega$

| Frequency<br>(GHz) | S <sub>11</sub> |                | S <sub>21</sub> |                | S <sub>12</sub> |                | S <sub>22</sub> |                |
|--------------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|
|                    | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) |
| 0.1                | 0.971           | -8.1           | 3.566           | 171.3          | 0.027           | 81.0           | 0.996           | -4.3           |
| 0.2                | 0.964           | -15.7          | 3.474           | 165.9          | 0.052           | 79.6           | 0.982           | -9.1           |
| 0.3                | 0.927           | -24.6          | 3.380           | 159.0          | 0.078           | 74.5           | 0.971           | -13.4          |
| 0.4                | 0.916           | -33.3          | 3.330           | 151.6          | 0.101           | 69.3           | 0.942           | -18.2          |
| 0.5                | 0.891           | -40.9          | 3.277           | 145.0          | 0.124           | 64.4           | 0.920           | -22.4          |
| 0.6                | 0.841           | -48.6          | 3.145           | 137.9          | 0.143           | 59.5           | 0.875           | -26.8          |
| 0.7                | 0.808           | -56.4          | 3.043           | 132.2          | 0.160           | 55.5           | 0.846           | -30.5          |
| 0.8                | 0.765           | -63.4          | 2.920           | 125.9          | 0.174           | 51.4           | 0.800           | -34.3          |
| 0.9                | 0.723           | -70.7          | 2.786           | 120.9          | 0.186           | 47.8           | 0.766           | -37.8          |
| 1.0                | 0.692           | -77.7          | 2.669           | 115.6          | 0.196           | 44.6           | 0.723           | -41.1          |
| 1.1                | 0.654           | -84.7          | 2.554           | 110.4          | 0.205           | 41.4           | 0.696           | -44.2          |
| 1.2                | 0.627           | -91.5          | 2.461           | 105.7          | 0.212           | 38.9           | 0.662           | -47.0          |
| 1.3                | 0.599           | -98.3          | 2.338           | 101.3          | 0.218           | 36.1           | 0.642           | -49.7          |
| 1.4                | 0.568           | -104.7         | 2.241           | 96.6           | 0.222           | 33.6           | 0.609           | -52.1          |
| 1.5                | 0.545           | -110.7         | 2.141           | 92.9           | 0.227           | 31.6           | 0.593           | -54.4          |
| 1.6                | 0.522           | -117.1         | 2.052           | 88.9           | 0.229           | 29.6           | 0.563           | -56.4          |
| 1.7                | 0.511           | -122.8         | 1.976           | 85.6           | 0.231           | 27.9           | 0.547           | -58.5          |
| 1.8                | 0.487           | -128.7         | 1.894           | 81.6           | 0.232           | 26.4           | 0.521           | -59.9          |
| 1.9                | 0.475           | -133.2         | 1.824           | 78.9           | 0.232           | 25.1           | 0.506           | -61.9          |
| 2.0                | 0.475           | -139.3         | 1.750           | 75.6           | 0.233           | 24.2           | 0.486           | -63.4          |
| 2.1                | 0.469           | -144.3         | 1.694           | 72.9           | 0.233           | 23.3           | 0.473           | -65.4          |
| 2.2                | 0.465           | -148.5         | 1.651           | 70.4           | 0.232           | 22.5           | 0.457           | -66.8          |
| 2.3                | 0.458           | -152.9         | 1.588           | 67.3           | 0.232           | 21.9           | 0.450           | -69.0          |
| 2.4                | 0.453           | -157.7         | 1.548           | 65.4           | 0.230           | 21.1           | 0.437           | -70.3          |
| 2.5                | 0.455           | -162.1         | 1.493           | 63.0           | 0.230           | 20.7           | 0.431           | -72.4          |
| 2.6                | 0.454           | -166.1         | 1.451           | 59.9           | 0.228           | 19.3           | 0.426           | -74.1          |
| 2.7                | 0.455           | -169.4         | 1.416           | 58.0           | 0.228           | 19.0           | 0.420           | -75.9          |
| 2.8                | 0.455           | -172.9         | 1.372           | 55.6           | 0.227           | 18.4           | 0.413           | -77.0          |
| 2.9                | 0.455           | -176.0         | 1.336           | 53.6           | 0.229           | 19.0           | 0.405           | -78.6          |
| 3.0                | 0.450           | -179.8         | 1.300           | 51.6           | 0.227           | 19.0           | 0.394           | -79.7          |
| 4.0                | 0.482           | 150.1          | 1.044           | 32.6           | 0.229           | 24.6           | 0.348           | -99.2          |
| 5.0                | 0.566           | 128.8          | 0.891           | 17.6           | 0.268           | 28.8           | 0.305           | -125.4         |



$V_{CE} = 1\text{ V}$ ,  $I_C = 3\text{ mA}$ ,  $Z_0 = 50\ \Omega$

| Frequency<br>(GHz) | S <sub>11</sub> |                | S <sub>21</sub> |                | S <sub>12</sub> |                | S <sub>22</sub> |                |
|--------------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|
|                    | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) |
| 0.1                | 0.883           | -14.4          | 9.519           | 167.2          | 0.025           | 80.6           | 0.967           | -9.5           |
| 0.2                | 0.866           | -28.0          | 9.012           | 156.4          | 0.049           | 74.3           | 0.921           | -18.9          |
| 0.3                | 0.790           | -42.0          | 8.353           | 146.6          | 0.069           | 67.3           | 0.868           | -27.0          |
| 0.4                | 0.744           | -54.7          | 7.772           | 136.7          | 0.086           | 61.2           | 0.793           | -34.6          |
| 0.5                | 0.683           | -66.2          | 7.206           | 128.4          | 0.100           | 56.1           | 0.727           | -40.6          |
| 0.6                | 0.612           | -76.5          | 6.513           | 121.1          | 0.111           | 52.3           | 0.650           | -46.1          |
| 0.7                | 0.564           | -86.0          | 5.991           | 115.2          | 0.119           | 49.7           | 0.596           | -50.4          |
| 0.8                | 0.517           | -94.6          | 5.468           | 109.5          | 0.126           | 47.5           | 0.537           | -54.5          |
| 0.9                | 0.477           | -103.5         | 5.016           | 105.0          | 0.133           | 45.7           | 0.494           | -58.3          |
| 1.0                | 0.451           | -111.5         | 4.637           | 100.7          | 0.138           | 44.6           | 0.450           | -61.5          |
| 1.1                | 0.423           | -119.5         | 4.290           | 96.5           | 0.143           | 43.6           | 0.421           | -64.6          |
| 1.2                | 0.407           | -126.9         | 4.019           | 92.8           | 0.148           | 43.1           | 0.389           | -67.7          |
| 1.3                | 0.393           | -133.4         | 3.742           | 89.6           | 0.152           | 42.1           | 0.370           | -70.2          |
| 1.4                | 0.379           | -140.3         | 3.506           | 86.1           | 0.156           | 41.7           | 0.343           | -72.7          |
| 1.5                | 0.370           | -146.4         | 3.308           | 83.4           | 0.160           | 41.5           | 0.330           | -74.6          |
| 1.6                | 0.363           | -152.7         | 3.116           | 80.3           | 0.165           | 41.2           | 0.306           | -76.8          |
| 1.7                | 0.363           | -158.0         | 2.961           | 78.0           | 0.168           | 40.9           | 0.294           | -78.7          |
| 1.8                | 0.354           | -163.9         | 2.811           | 75.0           | 0.172           | 40.9           | 0.274           | -80.7          |
| 1.9                | 0.349           | -167.1         | 2.688           | 73.0           | 0.176           | 40.8           | 0.265           | -83.0          |
| 2.0                | 0.358           | -172.3         | 2.549           | 70.5           | 0.181           | 40.9           | 0.248           | -84.9          |
| 2.1                | 0.363           | -176.0         | 2.447           | 68.4           | 0.185           | 40.8           | 0.242           | -87.6          |
| 2.2                | 0.366           | -179.3         | 2.366           | 66.6           | 0.189           | 40.9           | 0.228           | -89.5          |
| 2.3                | 0.365           | 177.7          | 2.274           | 64.1           | 0.194           | 40.8           | 0.224           | -92.2          |
| 2.4                | 0.369           | 173.5          | 2.199           | 62.6           | 0.198           | 40.7           | 0.215           | -93.8          |
| 2.5                | 0.375           | 170.7          | 2.105           | 60.9           | 0.202           | 40.7           | 0.212           | -96.7          |
| 2.6                | 0.380           | 167.4          | 2.034           | 58.4           | 0.206           | 40.0           | 0.207           | -98.0          |
| 2.7                | 0.382           | 164.9          | 1.984           | 56.9           | 0.211           | 39.9           | 0.204           | -100.5         |
| 2.8                | 0.387           | 162.1          | 1.914           | 54.9           | 0.215           | 39.6           | 0.197           | -101.5         |
| 2.9                | 0.387           | 160.4          | 1.860           | 53.6           | 0.221           | 39.9           | 0.193           | -104.1         |
| 3.0                | 0.388           | 157.2          | 1.803           | 51.9           | 0.226           | 39.7           | 0.184           | -105.3         |
| 4.0                | 0.434           | 136.1          | 1.401           | 35.4           | 0.274           | 38.0           | 0.169           | -133.8         |
| 5.0                | 0.520           | 121.2          | 1.190           | 21.7           | 0.328           | 32.4           | 0.158           | -175.1         |

$V_{CE} = 1\text{ V}$ ,  $I_C = 5\text{ mA}$ ,  $Z_0 = 50\ \Omega$

| Frequency<br>(GHz) | S <sub>11</sub> |                | S <sub>21</sub> |                | S <sub>12</sub> |                | S <sub>22</sub> |                |
|--------------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|
|                    | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) |
| 0.1                | 0.823           | -19.6          | 14.258          | 163.1          | 0.023           | 76.9           | 0.934           | -13.8          |
| 0.2                | 0.779           | -38.1          | 13.039          | 149.3          | 0.046           | 70.4           | 0.856           | -26.5          |
| 0.3                | 0.675           | -55.3          | 11.517          | 137.8          | 0.062           | 63.1           | 0.766           | -36.6          |
| 0.4                | 0.612           | -69.7          | 10.235          | 127.2          | 0.075           | 58.4           | 0.668           | -45.0          |
| 0.5                | 0.549           | -82.9          | 9.077           | 118.8          | 0.085           | 54.6           | 0.589           | -51.2          |
| 0.6                | 0.484           | -93.9          | 7.976           | 112.2          | 0.092           | 52.4           | 0.510           | -56.7          |
| 0.7                | 0.441           | -104.1         | 7.156           | 106.9          | 0.099           | 51.1           | 0.456           | -60.9          |
| 0.8                | 0.403           | -113.5         | 6.422           | 101.8          | 0.105           | 50.3           | 0.403           | -65.2          |
| 0.9                | 0.378           | -122.7         | 5.818           | 98.1           | 0.111           | 49.8           | 0.365           | -68.7          |
| 1.0                | 0.364           | -130.7         | 5.305           | 94.4           | 0.118           | 49.7           | 0.329           | -72.5          |
| 1.1                | 0.347           | -138.7         | 4.871           | 90.9           | 0.123           | 49.6           | 0.306           | -75.7          |
| 1.2                | 0.341           | -145.6         | 4.515           | 87.6           | 0.129           | 49.7           | 0.281           | -79.3          |
| 1.3                | 0.336           | -151.8         | 4.189           | 85.0           | 0.134           | 49.2           | 0.267           | -81.8          |
| 1.4                | 0.330           | -158.4         | 3.909           | 82.0           | 0.140           | 49.2           | 0.246           | -85.0          |
| 1.5                | 0.327           | -163.4         | 3.671           | 79.6           | 0.146           | 49.4           | 0.236           | -86.9          |
| 1.6                | 0.327           | -169.3         | 3.449           | 77.0           | 0.152           | 49.3           | 0.217           | -90.1          |
| 1.7                | 0.333           | -173.7         | 3.266           | 74.9           | 0.157           | 49.1           | 0.210           | -92.3          |
| 1.8                | 0.328           | -179.2         | 3.092           | 72.5           | 0.163           | 49.1           | 0.193           | -95.4          |
| 1.9                | 0.328           | 178.1          | 2.956           | 70.7           | 0.169           | 49.0           | 0.188           | -98.2          |
| 2.0                | 0.338           | 174.4          | 2.795           | 68.4           | 0.175           | 49.0           | 0.174           | -101.6         |
| 2.1                | 0.344           | 171.6          | 2.681           | 66.5           | 0.181           | 48.6           | 0.172           | -105.0         |
| 2.2                | 0.349           | 168.4          | 2.587           | 64.9           | 0.187           | 48.6           | 0.162           | -107.8         |
| 2.3                | 0.351           | 166.1          | 2.484           | 62.6           | 0.193           | 48.3           | 0.162           | -111.5         |
| 2.4                | 0.356           | 162.9          | 2.397           | 61.4           | 0.199           | 48.0           | 0.155           | -113.7         |
| 2.5                | 0.361           | 160.7          | 2.294           | 59.8           | 0.204           | 47.8           | 0.155           | -117.2         |
| 2.6                | 0.368           | 157.7          | 2.214           | 57.7           | 0.210           | 47.1           | 0.150           | -119.1         |
| 2.7                | 0.372           | 156.1          | 2.158           | 56.2           | 0.215           | 46.7           | 0.150           | -122.1         |
| 2.8                | 0.376           | 153.3          | 2.082           | 54.5           | 0.222           | 46.0           | 0.144           | -123.7         |
| 2.9                | 0.377           | 151.9          | 2.020           | 53.1           | 0.229           | 45.9           | 0.144           | -127.1         |
| 3.0                | 0.378           | 149.4          | 1.956           | 51.7           | 0.234           | 45.5           | 0.136           | -129.5         |
| 4.0                | 0.426           | 131.6          | 1.507           | 36.0           | 0.290           | 41.0           | 0.150           | -160.8         |
| 5.0                | 0.511           | 118.5          | 1.273           | 22.9           | 0.346           | 33.2           | 0.173           | 158.0          |

$V_{CE} = 1\text{ V}$ ,  $I_C = 7\text{ mA}$ ,  $Z_0 = 50\ \Omega$

| Frequency<br>(GHz) | S <sub>11</sub> |                | S <sub>21</sub> |                | S <sub>12</sub> |                | S <sub>22</sub> |                |
|--------------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|
|                    | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) |
| 0.1                | 0.767           | -24.3          | 17.973          | 159.9          | 0.022           | 78.5           | 0.905           | -17.4          |
| 0.2                | 0.694           | -46.3          | 15.883          | 143.9          | 0.042           | 67.6           | 0.797           | -32.2          |
| 0.3                | 0.587           | -65.4          | 13.504          | 131.7          | 0.056           | 61.6           | 0.686           | -43.2          |
| 0.4                | 0.525           | -81.0          | 11.608          | 121.2          | 0.067           | 57.7           | 0.579           | -51.9          |
| 0.5                | 0.467           | -94.6          | 10.043          | 113.2          | 0.075           | 55.3           | 0.499           | -57.8          |
| 0.6                | 0.410           | -106.0         | 8.675           | 107.1          | 0.083           | 54.2           | 0.425           | -63.4          |
| 0.7                | 0.377           | -116.7         | 7.713           | 102.3          | 0.089           | 54.0           | 0.375           | -67.4          |
| 0.8                | 0.348           | -126.2         | 6.862           | 97.7           | 0.096           | 53.8           | 0.328           | -71.9          |
| 0.9                | 0.336           | -135.5         | 6.172           | 94.4           | 0.102           | 53.6           | 0.296           | -75.6          |
| 1.0                | 0.326           | -143.1         | 5.610           | 91.1           | 0.109           | 53.8           | 0.266           | -80.0          |
| 1.1                | 0.318           | -150.4         | 5.124           | 88.0           | 0.115           | 54.0           | 0.247           | -83.5          |
| 1.2                | 0.317           | -157.1         | 4.733           | 85.0           | 0.122           | 54.2           | 0.227           | -87.7          |
| 1.3                | 0.314           | -162.4         | 4.384           | 82.6           | 0.128           | 53.9           | 0.216           | -90.4          |
| 1.4                | 0.315           | -168.7         | 4.082           | 79.8           | 0.135           | 53.9           | 0.199           | -94.4          |
| 1.5                | 0.317           | -173.4         | 3.832           | 77.7           | 0.142           | 54.0           | 0.193           | -96.5          |
| 1.6                | 0.317           | -178.7         | 3.594           | 75.3           | 0.148           | 53.8           | 0.176           | -100.6         |
| 1.7                | 0.325           | 177.7          | 3.395           | 73.4           | 0.155           | 53.5           | 0.172           | -103.0         |
| 1.8                | 0.327           | 172.8          | 3.218           | 71.1           | 0.161           | 53.4           | 0.158           | -107.4         |
| 1.9                | 0.323           | 170.6          | 3.075           | 69.4           | 0.168           | 53.2           | 0.156           | -110.6         |
| 2.0                | 0.334           | 167.1          | 2.903           | 67.3           | 0.175           | 53.0           | 0.145           | -115.2         |
| 2.1                | 0.341           | 164.7          | 2.781           | 65.5           | 0.182           | 52.5           | 0.145           | -118.9         |
| 2.2                | 0.347           | 162.5          | 2.684           | 64.0           | 0.188           | 52.3           | 0.138           | -122.8         |
| 2.3                | 0.348           | 160.2          | 2.576           | 61.8           | 0.195           | 51.7           | 0.140           | -126.5         |
| 2.4                | 0.354           | 157.3          | 2.488           | 60.7           | 0.201           | 51.4           | 0.135           | -129.4         |
| 2.5                | 0.360           | 155.5          | 2.376           | 59.2           | 0.207           | 50.9           | 0.137           | -132.8         |
| 2.6                | 0.367           | 153.0          | 2.294           | 57.2           | 0.213           | 50.2           | 0.134           | -135.2         |
| 2.7                | 0.369           | 151.3          | 2.233           | 55.7           | 0.219           | 49.7           | 0.135           | -138.4         |
| 2.8                | 0.376           | 149.0          | 2.153           | 54.1           | 0.226           | 48.9           | 0.130           | -140.6         |
| 2.9                | 0.377           | 148.0          | 2.091           | 52.7           | 0.233           | 48.6           | 0.132           | -143.7         |
| 3.0                | 0.379           | 145.5          | 2.025           | 51.3           | 0.239           | 48.0           | 0.125           | -147.1         |
| 4.0                | 0.425           | 129.2          | 1.554           | 36.3           | 0.299           | 42.3           | 0.155           | -175.2         |
| 5.0                | 0.509           | 116.7          | 1.310           | 23.5           | 0.355           | 33.5           | 0.194           | 147.6          |

$V_{CE} = 1\text{ V}$ ,  $I_C = 10\text{ mA}$ ,  $Z_O = 50\ \Omega$

| Frequency<br>(GHz) | S <sub>11</sub> |                | S <sub>21</sub> |                | S <sub>12</sub> |                | S <sub>22</sub> |                |
|--------------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|
|                    | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) |
| 0.1                | 0.686           | -31.4          | 22.299          | 156.2          | 0.021           | 77.4           | 0.860           | -21.8          |
| 0.2                | 0.601           | -55.9          | 18.761          | 137.7          | 0.038           | 66.2           | 0.721           | -38.9          |
| 0.3                | 0.492           | -77.4          | 15.302          | 125.4          | 0.050           | 60.2           | 0.594           | -50.3          |
| 0.4                | 0.436           | -93.6          | 12.698          | 115.3          | 0.060           | 58.5           | 0.486           | -59.0          |
| 0.5                | 0.393           | -108.4         | 10.732          | 108.0          | 0.067           | 57.5           | 0.411           | -64.7          |
| 0.6                | 0.350           | -120.2         | 9.197           | 102.5          | 0.075           | 57.2           | 0.344           | -70.4          |
| 0.7                | 0.327           | -130.3         | 8.080           | 98.2           | 0.082           | 57.7           | 0.301           | -74.4          |
| 0.8                | 0.314           | -140.0         | 7.158           | 94.2           | 0.089           | 58.0           | 0.262           | -79.5          |
| 0.9                | 0.306           | -148.6         | 6.424           | 91.1           | 0.096           | 58.0           | 0.236           | -83.6          |
| 1.0                | 0.304           | -155.9         | 5.812           | 88.2           | 0.104           | 58.2           | 0.212           | -88.9          |
| 1.1                | 0.302           | -162.3         | 5.294           | 85.4           | 0.111           | 58.4           | 0.198           | -92.8          |
| 1.2                | 0.305           | -168.0         | 4.879           | 82.8           | 0.118           | 58.6           | 0.183           | -98.0          |
| 1.3                | 0.305           | -172.9         | 4.506           | 80.5           | 0.125           | 58.3           | 0.176           | -101.0         |
| 1.4                | 0.308           | -178.2         | 4.181           | 77.9           | 0.132           | 58.1           | 0.163           | -106.1         |
| 1.5                | 0.312           | 177.9          | 3.936           | 76.0           | 0.140           | 58.0           | 0.159           | -108.3         |
| 1.6                | 0.317           | 173.3          | 3.688           | 73.7           | 0.147           | 57.8           | 0.147           | -113.7         |
| 1.7                | 0.324           | 170.7          | 3.483           | 72.0           | 0.154           | 57.4           | 0.145           | -116.3         |
| 1.8                | 0.327           | 165.7          | 3.298           | 69.9           | 0.161           | 57.1           | 0.135           | -122.1         |
| 1.9                | 0.325           | 163.5          | 3.149           | 68.3           | 0.168           | 56.7           | 0.136           | -125.4         |
| 2.0                | 0.337           | 161.0          | 2.974           | 66.3           | 0.176           | 56.2           | 0.128           | -131.3         |
| 2.1                | 0.346           | 159.1          | 2.848           | 64.6           | 0.183           | 55.6           | 0.132           | -134.7         |
| 2.2                | 0.348           | 157.5          | 2.744           | 63.2           | 0.191           | 55.2           | 0.127           | -139.4         |
| 2.3                | 0.350           | 155.5          | 2.637           | 61.1           | 0.198           | 54.6           | 0.131           | -142.9         |
| 2.4                | 0.356           | 152.9          | 2.544           | 60.1           | 0.204           | 54.1           | 0.127           | -146.0         |
| 2.5                | 0.364           | 151.2          | 2.431           | 58.5           | 0.211           | 53.4           | 0.132           | -148.9         |
| 2.6                | 0.371           | 148.8          | 2.348           | 56.6           | 0.217           | 52.6           | 0.129           | -151.5         |
| 2.7                | 0.372           | 147.3          | 2.282           | 55.2           | 0.224           | 51.9           | 0.132           | -154.2         |
| 2.8                | 0.379           | 145.5          | 2.205           | 53.6           | 0.231           | 51.1           | 0.129           | -157.0         |
| 2.9                | 0.380           | 144.4          | 2.139           | 52.3           | 0.238           | 50.6           | 0.132           | -159.5         |
| 3.0                | 0.382           | 142.1          | 2.070           | 51.1           | 0.245           | 49.9           | 0.127           | -163.5         |
| 4.0                | 0.427           | 127.2          | 1.585           | 36.2           | 0.306           | 43.2           | 0.167           | 173.4          |
| 5.0                | 0.512           | 115.7          | 1.331           | 23.8           | 0.362           | 33.6           | 0.217           | 140.7          |

$V_{CE} = 1\text{ V}$ ,  $I_C = 20\text{ mA}$ ,  $Z_O = 50\ \Omega$

| Frequency<br>(GHz) | S <sub>11</sub> |                | S <sub>21</sub> |                | S <sub>12</sub> |                | S <sub>22</sub> |                |
|--------------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|
|                    | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) |
| 0.1                | 0.484           | -48.9          | 29.552          | 147.4          | 0.019           | 68.5           | 0.739           | -30.9          |
| 0.2                | 0.429           | -82.6          | 22.187          | 126.4          | 0.033           | 64.3           | 0.553           | -50.9          |
| 0.3                | 0.359           | -108.0         | 16.755          | 115.0          | 0.041           | 62.9           | 0.422           | -62.0          |
| 0.4                | 0.336           | -124.9         | 13.327          | 106.4          | 0.049           | 63.1           | 0.331           | -70.3          |
| 0.5                | 0.324           | -137.8         | 10.970          | 100.2          | 0.058           | 63.4           | 0.272           | -75.4          |
| 0.6                | 0.309           | -148.6         | 9.266           | 95.8           | 0.066           | 64.0           | 0.223           | -81.8          |
| 0.7                | 0.308           | -157.2         | 8.062           | 92.5           | 0.074           | 64.7           | 0.193           | -86.3          |
| 0.8                | 0.303           | -164.5         | 7.101           | 88.9           | 0.082           | 65.0           | 0.167           | -93.2          |
| 0.9                | 0.310           | -171.3         | 6.344           | 86.5           | 0.090           | 64.9           | 0.152           | -98.4          |
| 1.0                | 0.317           | -175.9         | 5.722           | 83.9           | 0.098           | 64.8           | 0.139           | -106.0         |
| 1.1                | 0.319           | 179.4          | 5.196           | 81.6           | 0.107           | 64.8           | 0.133           | -110.9         |
| 1.2                | 0.325           | 175.3          | 4.786           | 79.2           | 0.115           | 64.5           | 0.126           | -118.0         |
| 1.3                | 0.329           | 172.1          | 4.413           | 77.3           | 0.123           | 63.9           | 0.124           | -121.1         |
| 1.4                | 0.337           | 168.5          | 4.092           | 74.9           | 0.130           | 63.5           | 0.119           | -128.0         |
| 1.5                | 0.340           | 165.3          | 3.845           | 73.2           | 0.139           | 63.1           | 0.118           | -130.0         |
| 1.6                | 0.347           | 161.7          | 3.598           | 71.1           | 0.146           | 62.6           | 0.113           | -137.4         |
| 1.7                | 0.354           | 159.7          | 3.394           | 69.6           | 0.154           | 62.0           | 0.114           | -139.7         |
| 1.8                | 0.359           | 156.1          | 3.214           | 67.6           | 0.162           | 61.3           | 0.111           | -147.3         |
| 1.9                | 0.357           | 154.7          | 3.070           | 66.0           | 0.169           | 60.7           | 0.115           | -149.7         |
| 2.0                | 0.366           | 153.0          | 2.896           | 64.2           | 0.178           | 60.1           | 0.113           | -156.7         |
| 2.1                | 0.378           | 151.3          | 2.773           | 62.6           | 0.186           | 59.2           | 0.119           | -158.9         |
| 2.2                | 0.379           | 149.8          | 2.672           | 61.3           | 0.193           | 58.5           | 0.118           | -163.7         |
| 2.3                | 0.382           | 148.3          | 2.563           | 59.2           | 0.201           | 57.7           | 0.125           | -166.0         |
| 2.4                | 0.389           | 146.1          | 2.474           | 58.3           | 0.207           | 56.9           | 0.123           | -169.2         |
| 2.5                | 0.395           | 144.6          | 2.363           | 56.8           | 0.215           | 56.3           | 0.130           | -170.8         |
| 2.6                | 0.403           | 143.1          | 2.279           | 55.0           | 0.222           | 55.2           | 0.128           | -173.6         |
| 2.7                | 0.403           | 141.7          | 2.214           | 53.8           | 0.229           | 54.3           | 0.133           | -175.3         |
| 2.8                | 0.409           | 139.9          | 2.141           | 52.3           | 0.235           | 53.4           | 0.131           | -178.2         |
| 2.9                | 0.410           | 139.0          | 2.079           | 51.1           | 0.243           | 52.8           | 0.136           | -179.9         |
| 3.0                | 0.414           | 136.9          | 2.012           | 49.7           | 0.249           | 52.0           | 0.134           | 176.0          |
| 4.0                | 0.453           | 123.9          | 1.533           | 35.3           | 0.312           | 44.0           | 0.180           | 159.6          |
| 5.0                | 0.534           | 113.2          | 1.291           | 23.2           | 0.367           | 33.8           | 0.241           | 131.6          |

$V_{CE} = 2\text{ V}$ ,  $I_C = 1\text{ mA}$ ,  $Z_0 = 50\ \Omega$

| Frequency<br>(GHz) | S <sub>11</sub> |                | S <sub>21</sub> |                | S <sub>12</sub> |                | S <sub>22</sub> |                |
|--------------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|
|                    | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) |
| 0.1                | 0.976           | -8.2           | 3.527           | 172.1          | 0.022           | 84.4           | 0.999           | -3.5           |
| 0.2                | 0.974           | -14.0          | 3.453           | 167.1          | 0.044           | 81.3           | 0.987           | -7.5           |
| 0.3                | 0.939           | -22.0          | 3.367           | 160.9          | 0.065           | 76.4           | 0.978           | -11.3          |
| 0.4                | 0.926           | -29.7          | 3.329           | 153.8          | 0.086           | 71.5           | 0.954           | -15.2          |
| 0.5                | 0.903           | -36.9          | 3.287           | 147.8          | 0.105           | 67.0           | 0.939           | -18.9          |
| 0.6                | 0.862           | -43.8          | 3.180           | 141.1          | 0.123           | 62.3           | 0.901           | -22.7          |
| 0.7                | 0.829           | -51.1          | 3.092           | 135.7          | 0.138           | 58.7           | 0.876           | -26.0          |
| 0.8                | 0.790           | -57.6          | 2.982           | 129.7          | 0.150           | 54.8           | 0.834           | -29.2          |
| 0.9                | 0.746           | -64.1          | 2.862           | 124.8          | 0.163           | 51.4           | 0.806           | -32.4          |
| 1.0                | 0.714           | -70.9          | 2.759           | 119.8          | 0.172           | 48.3           | 0.765           | -35.3          |
| 1.1                | 0.678           | -77.7          | 2.652           | 114.6          | 0.180           | 45.2           | 0.741           | -38.2          |
| 1.2                | 0.647           | -84.1          | 2.566           | 110.0          | 0.187           | 42.8           | 0.708           | -40.6          |
| 1.3                | 0.619           | -90.4          | 2.446           | 105.6          | 0.194           | 39.9           | 0.689           | -43.1          |
| 1.4                | 0.588           | -96.5          | 2.356           | 101.0          | 0.198           | 37.6           | 0.659           | -45.2          |
| 1.5                | 0.560           | -102.6         | 2.256           | 97.3           | 0.203           | 35.6           | 0.644           | -47.4          |
| 1.6                | 0.537           | -108.4         | 2.166           | 93.3           | 0.206           | 33.6           | 0.614           | -49.2          |
| 1.7                | 0.521           | -114.1         | 2.092           | 90.0           | 0.208           | 31.8           | 0.599           | -51.1          |
| 1.8                | 0.494           | -119.8         | 2.008           | 86.1           | 0.209           | 30.4           | 0.574           | -52.5          |
| 1.9                | 0.483           | -124.4         | 1.934           | 83.3           | 0.210           | 29.1           | 0.558           | -54.3          |
| 2.0                | 0.472           | -130.5         | 1.859           | 80.1           | 0.211           | 28.2           | 0.537           | -55.3          |
| 2.1                | 0.467           | -135.7         | 1.804           | 77.2           | 0.212           | 27.2           | 0.524           | -57.3          |
| 2.2                | 0.460           | -140.3         | 1.756           | 74.8           | 0.211           | 26.6           | 0.508           | -58.4          |
| 2.3                | 0.453           | -144.6         | 1.694           | 71.6           | 0.212           | 25.9           | 0.501           | -60.2          |
| 2.4                | 0.445           | -149.6         | 1.648           | 69.7           | 0.211           | 25.1           | 0.488           | -61.5          |
| 2.5                | 0.443           | -154.2         | 1.587           | 67.3           | 0.210           | 24.7           | 0.480           | -63.3          |
| 2.6                | 0.440           | -158.7         | 1.547           | 64.3           | 0.210           | 23.3           | 0.476           | -65.0          |
| 2.7                | 0.439           | -162.0         | 1.510           | 62.3           | 0.209           | 23.2           | 0.469           | -66.6          |
| 2.8                | 0.439           | -166.0         | 1.463           | 59.7           | 0.209           | 22.6           | 0.463           | -67.4          |
| 2.9                | 0.436           | -169.4         | 1.424           | 57.7           | 0.211           | 23.2           | 0.452           | -68.7          |
| 3.0                | 0.430           | -173.2         | 1.385           | 55.8           | 0.210           | 23.3           | 0.442           | -69.7          |
| 4.0                | 0.457           | 154.5          | 1.112           | 36.5           | 0.215           | 29.3           | 0.389           | -86.6          |
| 5.0                | 0.540           | 131.5          | 0.948           | 21.3           | 0.256           | 33.9           | 0.331           | -108.2         |

$V_{CE} = 2\text{ V}$ ,  $I_C = 3\text{ mA}$ ,  $Z_0 = 50\ \Omega$

| Frequency<br>(GHz) | S <sub>11</sub> |                | S <sub>21</sub> |                | S <sub>12</sub> |                | S <sub>22</sub> |                |
|--------------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|
|                    | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) |
| 0.1                | 0.901           | -13.2          | 9.534           | 168.2          | 0.021           | 78.2           | 0.973           | -7.8           |
| 0.2                | 0.884           | -24.6          | 9.106           | 158.5          | 0.042           | 76.2           | 0.935           | -15.7          |
| 0.3                | 0.810           | -36.7          | 8.526           | 149.3          | 0.059           | 69.8           | 0.891           | -22.6          |
| 0.4                | 0.768           | -48.2          | 8.030           | 139.9          | 0.075           | 64.2           | 0.827           | -29.0          |
| 0.5                | 0.713           | -58.8          | 7.496           | 132.0          | 0.087           | 59.6           | 0.770           | -34.2          |
| 0.6                | 0.641           | -67.5          | 6.859           | 124.8          | 0.097           | 55.8           | 0.696           | -38.9          |
| 0.7                | 0.585           | -76.6          | 6.363           | 119.0          | 0.106           | 53.4           | 0.647           | -42.5          |
| 0.8                | 0.534           | -84.5          | 5.859           | 113.1          | 0.112           | 51.0           | 0.590           | -46.1          |
| 0.9                | 0.492           | -92.6          | 5.387           | 108.7          | 0.119           | 49.2           | 0.547           | -49.0          |
| 1.0                | 0.458           | -100.3         | 5.011           | 104.3          | 0.124           | 48.0           | 0.503           | -51.8          |
| 1.1                | 0.426           | -107.6         | 4.652           | 100.1          | 0.130           | 47.0           | 0.474           | -54.3          |
| 1.2                | 0.403           | -114.8         | 4.368           | 96.3           | 0.134           | 46.4           | 0.441           | -56.5          |
| 1.3                | 0.385           | -121.4         | 4.069           | 93.1           | 0.139           | 45.4           | 0.421           | -58.4          |
| 1.4                | 0.364           | -128.3         | 3.830           | 89.5           | 0.143           | 44.9           | 0.394           | -60.3          |
| 1.5                | 0.349           | -134.6         | 3.616           | 86.7           | 0.148           | 44.7           | 0.380           | -61.8          |
| 1.6                | 0.337           | -141.0         | 3.411           | 83.7           | 0.151           | 44.3           | 0.355           | -63.2          |
| 1.7                | 0.334           | -146.9         | 3.245           | 81.3           | 0.155           | 44.1           | 0.343           | -64.8          |
| 1.8                | 0.322           | -153.5         | 3.080           | 78.2           | 0.159           | 44.0           | 0.322           | -65.8          |
| 1.9                | 0.318           | -156.7         | 2.944           | 76.3           | 0.163           | 43.9           | 0.311           | -67.6          |
| 2.0                | 0.322           | -162.3         | 2.795           | 73.8           | 0.167           | 44.0           | 0.293           | -68.6          |
| 2.1                | 0.325           | -167.0         | 2.686           | 71.7           | 0.172           | 43.9           | 0.284           | -70.7          |
| 2.2                | 0.328           | -170.3         | 2.597           | 69.8           | 0.176           | 43.9           | 0.271           | -71.6          |
| 2.3                | 0.326           | -174.3         | 2.495           | 67.4           | 0.180           | 43.9           | 0.266           | -73.8          |
| 2.4                | 0.328           | -178.4         | 2.411           | 66.0           | 0.184           | 43.7           | 0.256           | -74.7          |
| 2.5                | 0.330           | 178.0          | 2.304           | 64.1           | 0.188           | 43.8           | 0.251           | -77.0          |
| 2.6                | 0.338           | 174.5          | 2.234           | 61.8           | 0.192           | 43.2           | 0.245           | -77.8          |
| 2.7                | 0.337           | 171.5          | 2.176           | 60.1           | 0.196           | 43.1           | 0.240           | -79.8          |
| 2.8                | 0.341           | 168.4          | 2.096           | 58.3           | 0.201           | 42.6           | 0.234           | -80.2          |
| 2.9                | 0.343           | 166.8          | 2.035           | 56.8           | 0.207           | 42.9           | 0.228           | -82.1          |
| 3.0                | 0.343           | 163.4          | 1.974           | 55.1           | 0.211           | 42.8           | 0.219           | -82.4          |
| 4.0                | 0.391           | 140.1          | 1.534           | 38.6           | 0.258           | 41.5           | 0.183           | -105.5         |
| 5.0                | 0.478           | 124.1          | 1.296           | 24.8           | 0.313           | 36.3           | 0.130           | -140.9         |

$V_{CE} = 2 \text{ V}$ ,  $I_C = 5 \text{ mA}$ ,  $Z_0 = 50 \Omega$

| Frequency<br>(GHz) | S <sub>11</sub> |                | S <sub>21</sub> |                | S <sub>12</sub> |                | S <sub>22</sub> |                |
|--------------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|
|                    | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) |
| 0.1                | 0.849           | -17.3          | 14.332          | 164.5          | 0.019           | 84.6           | 0.947           | -11.2          |
| 0.2                | 0.804           | -32.8          | 13.240          | 151.9          | 0.038           | 72.3           | 0.880           | -21.8          |
| 0.3                | 0.705           | -47.5          | 11.913          | 141.0          | 0.053           | 66.1           | 0.805           | -30.3          |
| 0.4                | 0.641           | -60.8          | 10.727          | 130.8          | 0.065           | 61.6           | 0.714           | -37.4          |
| 0.5                | 0.574           | -72.7          | 9.646           | 122.6          | 0.075           | 57.9           | 0.640           | -42.6          |
| 0.6                | 0.502           | -82.2          | 8.564           | 115.7          | 0.083           | 55.5           | 0.563           | -47.1          |
| 0.7                | 0.451           | -91.4          | 7.731           | 110.4          | 0.090           | 54.4           | 0.511           | -50.3          |
| 0.8                | 0.408           | -100.4         | 6.974           | 105.3          | 0.095           | 53.4           | 0.456           | -53.4          |
| 0.9                | 0.374           | -108.7         | 6.341           | 101.4          | 0.102           | 52.6           | 0.418           | -56.0          |
| 1.0                | 0.351           | -116.7         | 5.810           | 97.6           | 0.107           | 52.4           | 0.380           | -58.5          |
| 1.1                | 0.329           | -124.7         | 5.338           | 94.1           | 0.113           | 52.2           | 0.355           | -60.8          |
| 1.2                | 0.313           | -131.9         | 4.969           | 90.7           | 0.118           | 52.4           | 0.328           | -63.0          |
| 1.3                | 0.306           | -138.4         | 4.609           | 88.0           | 0.124           | 51.9           | 0.312           | -64.8          |
| 1.4                | 0.295           | -145.9         | 4.307           | 84.8           | 0.129           | 51.9           | 0.289           | -66.7          |
| 1.5                | 0.288           | -151.8         | 4.052           | 82.6           | 0.135           | 51.9           | 0.279           | -68.0          |
| 1.6                | 0.284           | -158.2         | 3.809           | 80.0           | 0.140           | 51.7           | 0.258           | -69.5          |
| 1.7                | 0.288           | -163.6         | 3.605           | 78.0           | 0.146           | 51.6           | 0.250           | -71.0          |
| 1.8                | 0.278           | -169.6         | 3.421           | 75.4           | 0.151           | 51.6           | 0.231           | -72.3          |
| 1.9                | 0.277           | -173.0         | 3.265           | 73.5           | 0.156           | 51.5           | 0.224           | -74.4          |
| 2.0                | 0.290           | -177.4         | 3.095           | 71.4           | 0.162           | 51.5           | 0.208           | -75.7          |
| 2.1                | 0.296           | 178.5          | 2.962           | 69.4           | 0.168           | 51.2           | 0.202           | -78.4          |
| 2.2                | 0.298           | 175.9          | 2.860           | 67.9           | 0.174           | 51.1           | 0.191           | -79.5          |
| 2.3                | 0.298           | 173.0          | 2.749           | 65.7           | 0.180           | 50.9           | 0.187           | -82.4          |
| 2.4                | 0.303           | 169.5          | 2.651           | 64.4           | 0.185           | 50.6           | 0.179           | -83.3          |
| 2.5                | 0.310           | 166.7          | 2.537           | 62.8           | 0.190           | 50.3           | 0.176           | -86.4          |
| 2.6                | 0.315           | 163.5          | 2.448           | 60.8           | 0.195           | 49.6           | 0.171           | -87.1          |
| 2.7                | 0.317           | 161.5          | 2.380           | 59.2           | 0.201           | 49.2           | 0.167           | -89.7          |
| 2.8                | 0.323           | 158.6          | 2.300           | 57.5           | 0.207           | 48.6           | 0.161           | -90.0          |
| 2.9                | 0.324           | 156.9          | 2.230           | 56.0           | 0.214           | 48.5           | 0.157           | -92.6          |
| 3.0                | 0.326           | 153.9          | 2.158           | 54.6           | 0.219           | 48.2           | 0.148           | -93.2          |
| 4.0                | 0.375           | 134.9          | 1.660           | 39.0           | 0.274           | 44.2           | 0.130           | -124.7         |
| 5.0                | 0.465           | 121.2          | 1.400           | 26.0           | 0.329           | 36.8           | 0.107           | -176.8         |



$V_{CE} = 2\text{ V}$ ,  $I_C = 7\text{ mA}$ ,  $Z_0 = 50\ \Omega$

| Frequency<br>(GHz) | S <sub>11</sub> |                | S <sub>21</sub> |                | S <sub>12</sub> |                | S <sub>22</sub> |                |
|--------------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|
|                    | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) |
| 0.1                | 0.781           | -21.4          | 18.207          | 161.6          | 0.019           | 80.8           | 0.921           | -14.2          |
| 0.2                | 0.725           | -39.6          | 16.322          | 146.8          | 0.036           | 70.3           | 0.828           | -26.5          |
| 0.3                | 0.616           | -56.5          | 14.168          | 135.0          | 0.049           | 64.7           | 0.731           | -35.7          |
| 0.4                | 0.549           | -70.2          | 12.343          | 124.5          | 0.059           | 60.9           | 0.629           | -42.8          |
| 0.5                | 0.482           | -82.7          | 10.808          | 116.7          | 0.067           | 58.1           | 0.553           | -47.4          |
| 0.6                | 0.416           | -92.8          | 9.422           | 110.4          | 0.075           | 57.1           | 0.478           | -51.5          |
| 0.7                | 0.375           | -102.5         | 8.418           | 105.5          | 0.081           | 56.8           | 0.428           | -54.2          |
| 0.8                | 0.336           | -111.7         | 7.516           | 100.7          | 0.087           | 56.4           | 0.378           | -57.0          |
| 0.9                | 0.313           | -120.9         | 6.785           | 97.4           | 0.093           | 56.2           | 0.345           | -59.3          |
| 1.0                | 0.298           | -128.7         | 6.187           | 93.9           | 0.100           | 56.2           | 0.311           | -61.7          |
| 1.1                | 0.284           | -136.7         | 5.652           | 90.9           | 0.106           | 56.4           | 0.290           | -63.9          |
| 1.2                | 0.277           | -143.9         | 5.238           | 87.8           | 0.112           | 56.5           | 0.266           | -66.2          |
| 1.3                | 0.272           | -150.2         | 4.861           | 85.3           | 0.118           | 56.2           | 0.254           | -67.9          |
| 1.4                | 0.269           | -157.4         | 4.519           | 82.6           | 0.124           | 56.2           | 0.234           | -69.8          |
| 1.5                | 0.265           | -162.7         | 4.254           | 80.4           | 0.130           | 56.2           | 0.226           | -71.2          |
| 1.6                | 0.265           | -169.2         | 3.988           | 78.0           | 0.137           | 56.1           | 0.208           | -72.9          |
| 1.7                | 0.269           | -173.4         | 3.772           | 76.1           | 0.143           | 55.9           | 0.201           | -74.4          |
| 1.8                | 0.268           | -179.3         | 3.574           | 73.9           | 0.149           | 55.6           | 0.185           | -76.1          |
| 1.9                | 0.266           | 178.2          | 3.408           | 72.1           | 0.155           | 55.6           | 0.179           | -78.6          |
| 2.0                | 0.280           | 174.4          | 3.225           | 70.1           | 0.161           | 55.3           | 0.165           | -80.1          |
| 2.1                | 0.286           | 171.0          | 3.087           | 68.3           | 0.168           | 54.9           | 0.161           | -83.3          |
| 2.2                | 0.289           | 168.5          | 2.978           | 66.8           | 0.174           | 54.6           | 0.150           | -84.8          |
| 2.3                | 0.289           | 165.8          | 2.859           | 64.7           | 0.181           | 54.2           | 0.148           | -88.4          |
| 2.4                | 0.296           | 162.5          | 2.756           | 63.6           | 0.186           | 53.7           | 0.141           | -89.5          |
| 2.5                | 0.302           | 160.3          | 2.636           | 62.0           | 0.192           | 53.4           | 0.139           | -93.1          |
| 2.6                | 0.310           | 157.5          | 2.540           | 60.1           | 0.198           | 52.6           | 0.134           | -94.0          |
| 2.7                | 0.312           | 155.6          | 2.479           | 58.5           | 0.204           | 52.1           | 0.132           | -97.0          |
| 2.8                | 0.318           | 153.5          | 2.386           | 57.1           | 0.210           | 51.4           | 0.126           | -97.5          |
| 2.9                | 0.320           | 151.9          | 2.315           | 55.7           | 0.218           | 51.1           | 0.123           | -100.7         |
| 3.0                | 0.321           | 149.3          | 2.242           | 54.2           | 0.223           | 50.6           | 0.115           | -101.9         |
| 4.0                | 0.373           | 131.9          | 1.717           | 39.3           | 0.281           | 45.3           | 0.110           | -139.2         |
| 5.0                | 0.460           | 119.4          | 1.444           | 26.5           | 0.337           | 37.0           | 0.112           | 163.5          |

$V_{CE} = 2\text{ V}$ ,  $I_C = 10\text{ mA}$ ,  $Z_O = 50\ \Omega$

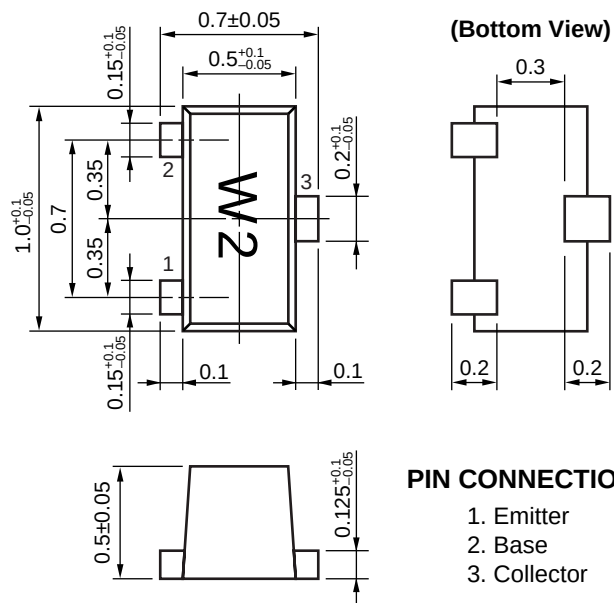
| Frequency<br>(GHz) | S <sub>11</sub> |                | S <sub>21</sub> |                | S <sub>12</sub> |                | S <sub>22</sub> |                |
|--------------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|
|                    | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) |
| 0.1                | 0.712           | -25.5          | 22.714          | 158.0          | 0.017           | 74.0           | 0.884           | -17.4          |
| 0.2                | 0.638           | -47.2          | 19.532          | 141.0          | 0.033           | 68.1           | 0.764           | -31.5          |
| 0.3                | 0.520           | -66.1          | 16.216          | 128.9          | 0.044           | 63.9           | 0.648           | -40.9          |
| 0.4                | 0.453           | -80.7          | 13.709          | 118.8          | 0.053           | 61.1           | 0.542           | -47.6          |
| 0.5                | 0.396           | -93.9          | 11.746          | 111.3          | 0.061           | 60.0           | 0.467           | -51.6          |
| 0.6                | 0.342           | -104.5         | 10.099          | 105.6          | 0.068           | 59.6           | 0.397           | -55.1          |
| 0.7                | 0.311           | -115.2         | 8.920           | 101.3          | 0.074           | 60.1           | 0.353           | -57.3          |
| 0.8                | 0.283           | -124.6         | 7.918           | 97.0           | 0.081           | 60.1           | 0.310           | -59.9          |
| 0.9                | 0.271           | -133.7         | 7.104           | 93.9           | 0.088           | 60.2           | 0.281           | -62.0          |
| 1.0                | 0.262           | -141.7         | 6.456           | 91.0           | 0.094           | 60.3           | 0.252           | -64.5          |
| 1.1                | 0.254           | -149.2         | 5.882           | 88.0           | 0.101           | 60.5           | 0.236           | -66.6          |
| 1.2                | 0.252           | -156.2         | 5.437           | 85.4           | 0.108           | 60.6           | 0.215           | -69.1          |
| 1.3                | 0.251           | -162.3         | 5.029           | 83.2           | 0.115           | 60.3           | 0.206           | -70.9          |
| 1.4                | 0.253           | -168.4         | 4.674           | 80.5           | 0.121           | 60.2           | 0.189           | -73.2          |
| 1.5                | 0.254           | -173.1         | 4.383           | 78.7           | 0.128           | 60.1           | 0.183           | -74.4          |
| 1.6                | 0.255           | -179.5         | 4.118           | 76.3           | 0.135           | 59.7           | 0.167           | -76.7          |
| 1.7                | 0.263           | 177.3          | 3.890           | 74.7           | 0.142           | 59.3           | 0.162           | -78.4          |
| 1.8                | 0.263           | 171.9          | 3.682           | 72.5           | 0.149           | 59.1           | 0.147           | -80.6          |
| 1.9                | 0.261           | 169.8          | 3.513           | 70.9           | 0.155           | 58.8           | 0.144           | -83.4          |
| 2.0                | 0.275           | 166.4          | 3.318           | 69.0           | 0.162           | 58.4           | 0.130           | -85.6          |
| 2.1                | 0.284           | 164.4          | 3.178           | 67.3           | 0.169           | 57.8           | 0.128           | -89.6          |
| 2.2                | 0.287           | 161.7          | 3.063           | 65.9           | 0.176           | 57.5           | 0.119           | -91.7          |
| 2.3                | 0.288           | 159.8          | 2.942           | 63.8           | 0.182           | 56.9           | 0.118           | -95.8          |
| 2.4                | 0.296           | 157.0          | 2.834           | 62.8           | 0.188           | 56.3           | 0.112           | -97.4          |
| 2.5                | 0.303           | 154.9          | 2.710           | 61.4           | 0.195           | 55.8           | 0.112           | -101.9         |
| 2.6                | 0.312           | 152.5          | 2.614           | 59.4           | 0.201           | 54.9           | 0.107           | -103.1         |
| 2.7                | 0.312           | 151.0          | 2.540           | 58.1           | 0.207           | 54.3           | 0.106           | -106.9         |
| 2.8                | 0.318           | 148.7          | 2.451           | 56.5           | 0.214           | 53.4           | 0.100           | -107.4         |
| 2.9                | 0.320           | 147.6          | 2.378           | 55.2           | 0.221           | 53.0           | 0.100           | -111.6         |
| 3.0                | 0.324           | 145.3          | 2.302           | 53.9           | 0.227           | 52.4           | 0.091           | -113.6         |
| 4.0                | 0.372           | 129.6          | 1.759           | 39.4           | 0.287           | 46.2           | 0.102           | -154.4         |
| 5.0                | 0.459           | 118.0          | 1.475           | 27.0           | 0.342           | 37.3           | 0.127           | 150.6          |

$V_{CE} = 2\text{ V}$ ,  $I_C = 20\text{ mA}$ ,  $Z_O = 50\ \Omega$

| Frequency<br>(GHz) | S <sub>11</sub> |                | S <sub>21</sub> |                | S <sub>12</sub> |                | S <sub>22</sub> |                |
|--------------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|
|                    | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) |
| 0.1                | 0.534           | -36.7          | 31.060          | 150.4          | 0.016           | 70.9           | 0.796           | -24.0          |
| 0.2                | 0.457           | -66.2          | 24.217          | 130.4          | 0.029           | 67.6           | 0.624           | -39.8          |
| 0.3                | 0.357           | -88.3          | 18.723          | 118.6          | 0.036           | 65.5           | 0.495           | -47.9          |
| 0.4                | 0.317           | -104.4         | 15.065          | 109.7          | 0.044           | 65.3           | 0.398           | -52.8          |
| 0.5                | 0.288           | -118.2         | 12.526          | 103.4          | 0.052           | 65.1           | 0.337           | -54.9          |
| 0.6                | 0.258           | -130.8         | 10.611          | 98.7           | 0.060           | 65.9           | 0.282           | -57.3          |
| 0.7                | 0.245           | -140.8         | 9.265           | 95.3           | 0.067           | 66.7           | 0.249           | -58.2          |
| 0.8                | 0.238           | -150.4         | 8.174           | 91.6           | 0.074           | 66.6           | 0.217           | -60.3          |
| 0.9                | 0.237           | -158.4         | 7.304           | 89.1           | 0.082           | 66.6           | 0.197           | -62.0          |
| 1.0                | 0.241           | -164.8         | 6.593           | 86.6           | 0.089           | 66.5           | 0.175           | -64.6          |
| 1.1                | 0.240           | -170.9         | 5.995           | 84.2           | 0.097           | 66.6           | 0.165           | -66.7          |
| 1.2                | 0.244           | -176.3         | 5.536           | 81.9           | 0.104           | 66.5           | 0.150           | -69.6          |
| 1.3                | 0.249           | -180.0         | 5.107           | 79.9           | 0.112           | 65.9           | 0.145           | -71.6          |
| 1.4                | 0.257           | 175.3          | 4.743           | 77.5           | 0.119           | 65.4           | 0.131           | -74.2          |
| 1.5                | 0.259           | 171.4          | 4.455           | 75.9           | 0.127           | 65.2           | 0.129           | -75.7          |
| 1.6                | 0.266           | 167.0          | 4.165           | 73.9           | 0.134           | 64.7           | 0.115           | -78.5          |
| 1.7                | 0.274           | 164.7          | 3.935           | 72.4           | 0.141           | 63.9           | 0.113           | -80.4          |
| 1.8                | 0.280           | 159.9          | 3.725           | 70.3           | 0.148           | 63.5           | 0.101           | -83.7          |
| 1.9                | 0.278           | 158.4          | 3.548           | 68.8           | 0.155           | 62.9           | 0.100           | -87.5          |
| 2.0                | 0.289           | 156.1          | 3.351           | 67.0           | 0.163           | 62.2           | 0.088           | -91.1          |
| 2.1                | 0.297           | 154.8          | 3.206           | 65.5           | 0.170           | 61.5           | 0.088           | -96.2          |
| 2.2                | 0.302           | 153.4          | 3.088           | 64.2           | 0.177           | 60.9           | 0.081           | -99.8          |
| 2.3                | 0.305           | 151.8          | 2.964           | 62.1           | 0.184           | 60.2           | 0.082           | -105.2         |
| 2.4                | 0.310           | 149.1          | 2.856           | 61.3           | 0.190           | 59.4           | 0.077           | -107.6         |
| 2.5                | 0.318           | 148.0          | 2.733           | 59.9           | 0.197           | 58.8           | 0.079           | -113.3         |
| 2.6                | 0.326           | 146.0          | 2.632           | 58.0           | 0.204           | 57.8           | 0.075           | -115.0         |
| 2.7                | 0.328           | 144.7          | 2.564           | 56.9           | 0.211           | 56.9           | 0.076           | -120.0         |
| 2.8                | 0.334           | 143.0          | 2.468           | 55.3           | 0.217           | 55.9           | 0.071           | -121.5         |
| 2.9                | 0.336           | 142.0          | 2.397           | 54.2           | 0.225           | 55.4           | 0.072           | -126.4         |
| 3.0                | 0.338           | 139.7          | 2.316           | 52.8           | 0.231           | 54.7           | 0.066           | -130.2         |
| 4.0                | 0.387           | 126.6          | 1.762           | 38.8           | 0.292           | 47.4           | 0.095           | -172.2         |
| 5.0                | 0.474           | 116.2          | 1.478           | 26.7           | 0.347           | 37.7           | 0.141           | 138.8          |

PACKAGE DIMENSIONS

3-PIN LEAD-LESS MINIMOLD (UNIT: mm)



PIN CONNECTIONS

1. Emitter
2. Base
3. Collector

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