

# DATA SHEET

# NEC

## NPN SILICON RF TRANSISTOR 2SC5617

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

#### FEATURES

- NF = 1.5 dB TYP. @  $V_{CE} = 3\text{ V}$ ,  $I_C = 3\text{ mA}$ ,  $f = 2\text{ GHz}$
- $|S_{21e}|^2 = 11.0\text{ dB}$  TYP. @  $V_{CE} = 3\text{ V}$ ,  $I_C = 10\text{ mA}$ ,  $f = 2\text{ GHz}$
- 3-pin lead-less minimold package

#### ORDERING INFORMATION

| Part Number | Quantity          | Supplying Form                                       |
|-------------|-------------------|------------------------------------------------------|
| 2SC5617     | 50 pcs (Non reel) | • 8 mm wide embossed taping                          |
| 2SC5617-T3  | 10 kpcs/reel      | • Pin 2 (Base) face the perforation side of the tape |

**Remark** To order evaluation samples, consult your NEC sales representative.  
Unit sample quantity is 50 pcs.

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

| Parameter                    | Symbol                    | Ratings     | Unit             |
|------------------------------|---------------------------|-------------|------------------|
| Collector to Base Voltage    | $V_{CBO}$                 | 9.0         | V                |
| Collector to Emitter Voltage | $V_{CEO}$                 | 6.0         | V                |
| Emitter to Base Voltage      | $V_{EBO}$                 | 2.0         | V                |
| Collector Current            | $I_C$                     | 30          | mA               |
| Total Power Dissipation      | $P_{tot}$ <sup>Note</sup> | 140         | 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.

The information in this document is subject to change without notice. Before using this document, please confirm that this is the latest version.  
Not all devices/types available in every country. Please check with local NEC representative for availability and additional information.

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

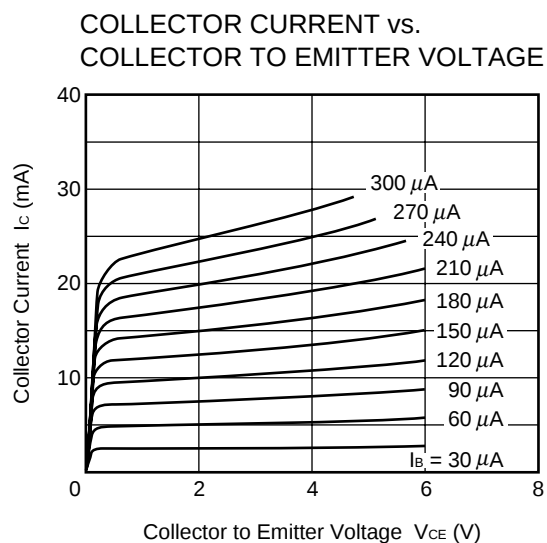
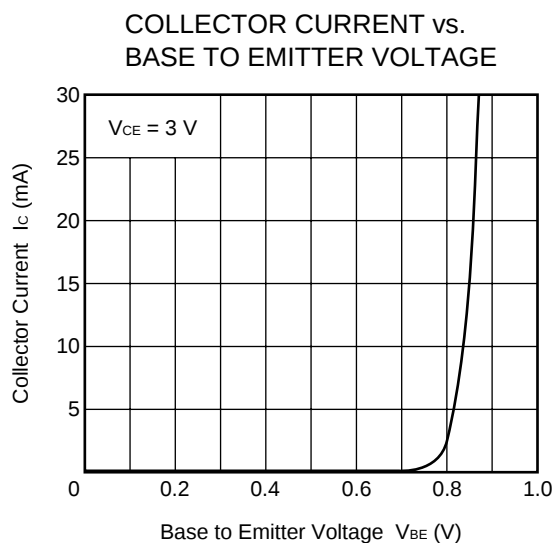
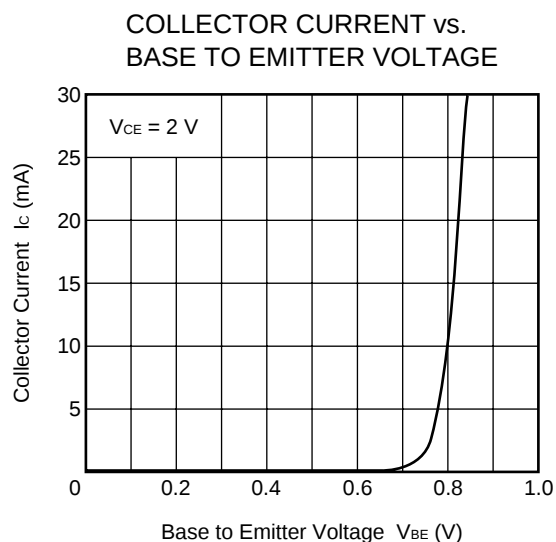
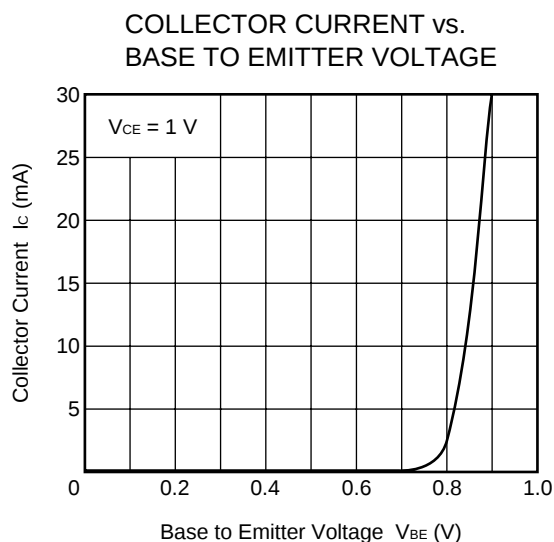
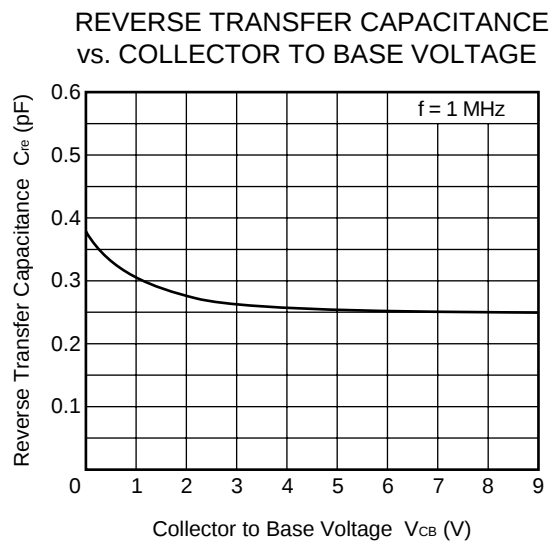
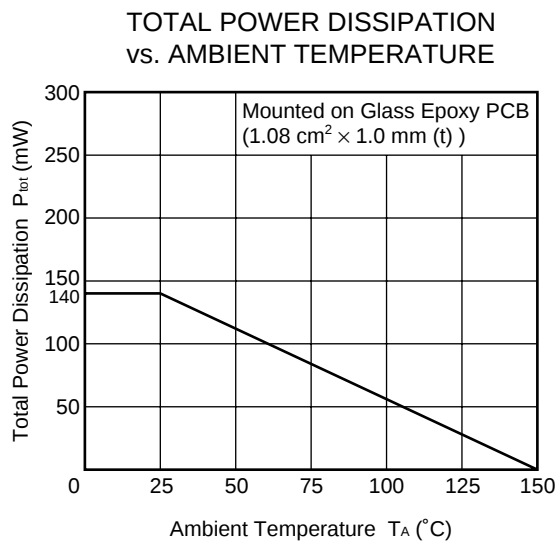
| Parameter                    | Symbol                            | Test Conditions                                                                               | MIN. | TYP. | MAX. | Unit |
|------------------------------|-----------------------------------|-----------------------------------------------------------------------------------------------|------|------|------|------|
| 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>BE</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> = 3 V, I <sub>C</sub> = 10 mA                                                 | 75   | —    | 140  | —    |
| RF Characteristics           |                                   |                                                                                               |      |      |      |      |
| Gain Bandwidth Product       | f <sub>T</sub>                    | V <sub>CE</sub> = 3 V, I <sub>C</sub> = 10 mA, f = 2 GHz                                      | —    | 12.0 | —    | GHz  |
| Insertion Power Gain         | S <sub>21e</sub>   <sup>2</sup>   | V <sub>CE</sub> = 3 V, I <sub>C</sub> = 10 mA, f = 2 GHz                                      | 7.0  | 11.0 | —    | dB   |
| Noise Figure                 | NF                                | V <sub>CE</sub> = 3 V, I <sub>C</sub> = 3 mA, f = 2 GHz,<br>Z <sub>S</sub> = Z <sub>opt</sub> | —    | 1.5  | 2.5  | dB   |
| Reverse Transfer Capacitance | C <sub>re</sub> <sup>Note 2</sup> | V <sub>CB</sub> = 3 V, I <sub>E</sub> = 0 mA, f = 1 MHz                                       | —    | 0.4  | 0.7  | pF   |

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

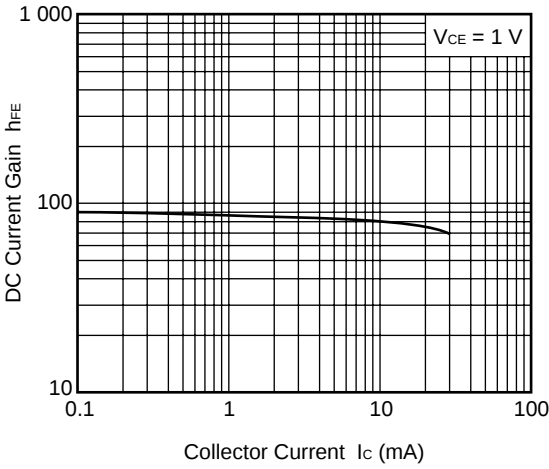
**h<sub>FE</sub> CLASSIFICATION**

| Rank                  | EB        | FB        |
|-----------------------|-----------|-----------|
| Marking               | Y1        | Y2        |
| h <sub>FE</sub> Value | 75 to 110 | 95 to 140 |

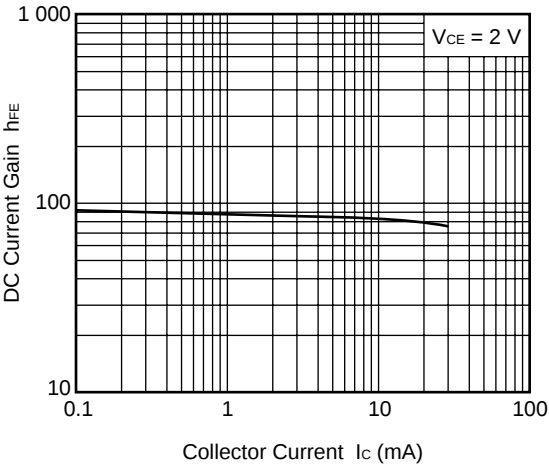
**TYPICAL CHARACTERISTICS (Unless otherwise specified,  $T_A = +25^\circ\text{C}$ )**



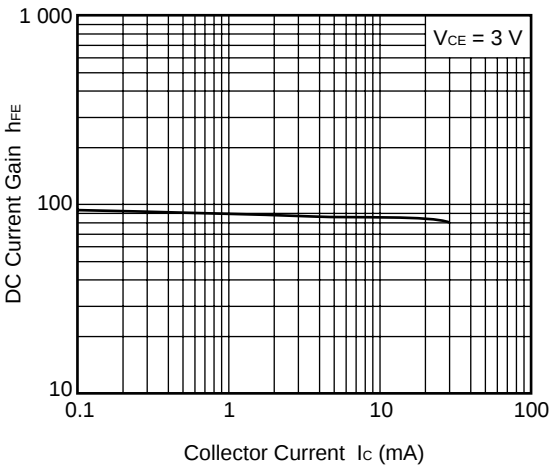
DC CURRENT GAIN vs.  
COLLECTOR CURRENT



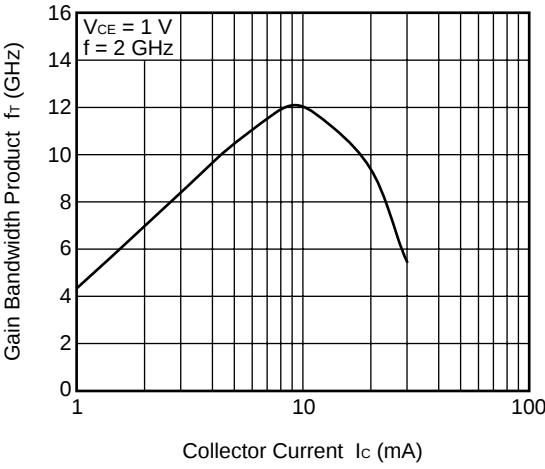
DC CURRENT GAIN vs.  
COLLECTOR CURRENT



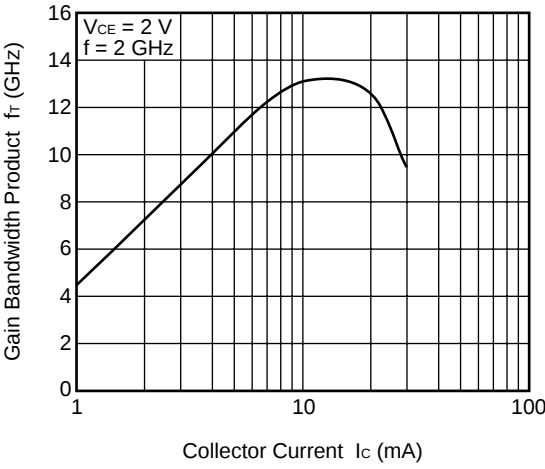
DC CURRENT GAIN vs.  
COLLECTOR CURRENT



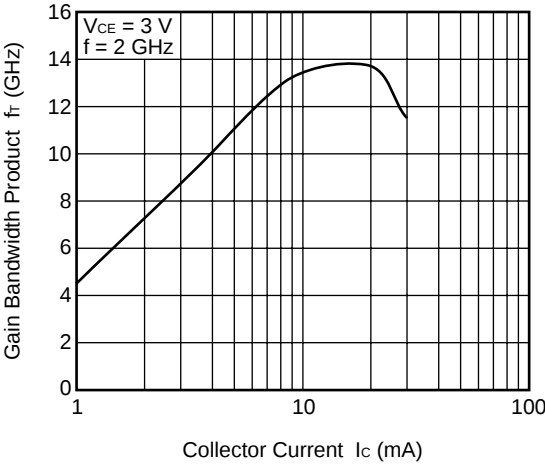
GAIN BANDWIDTH PRODUCT  
vs. COLLECTOR CURRENT



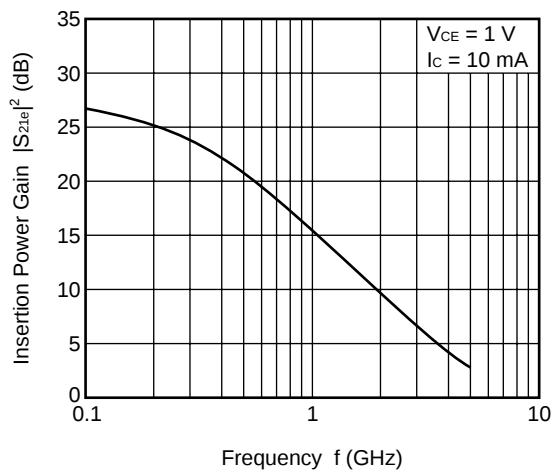
GAIN BANDWIDTH PRODUCT  
vs. COLLECTOR CURRENT



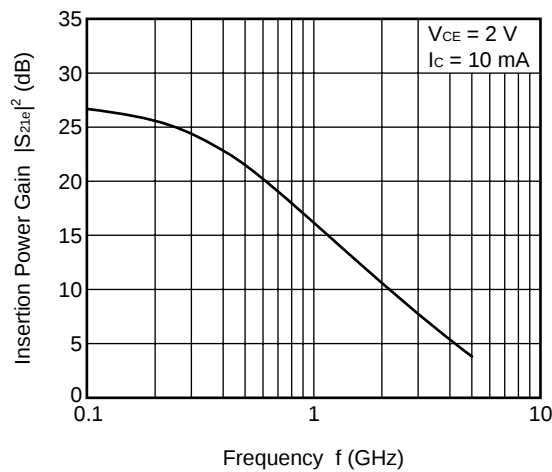
GAIN BANDWIDTH PRODUCT  
vs. COLLECTOR CURRENT



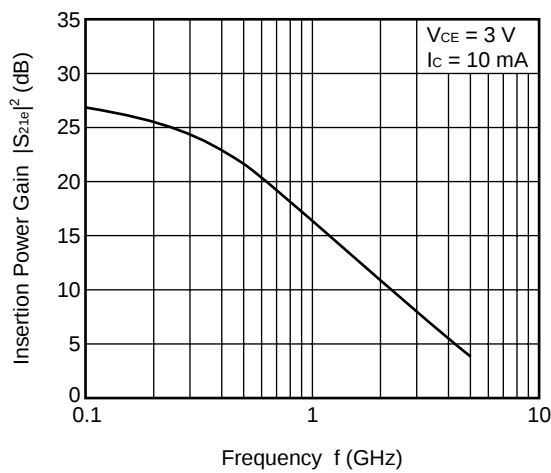
INSERTION POWER GAIN vs. FREQUENCY



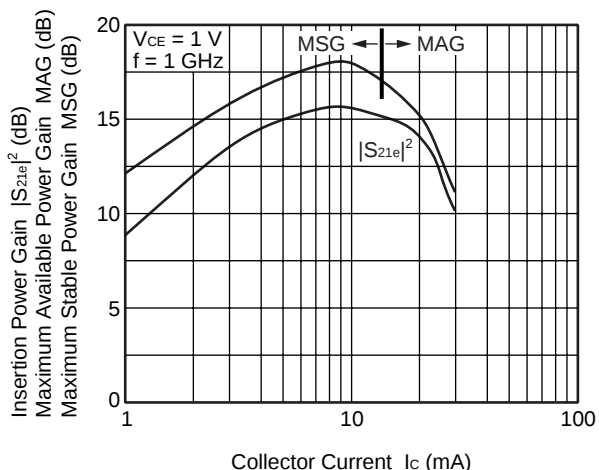
INSERTION POWER GAIN vs. FREQUENCY



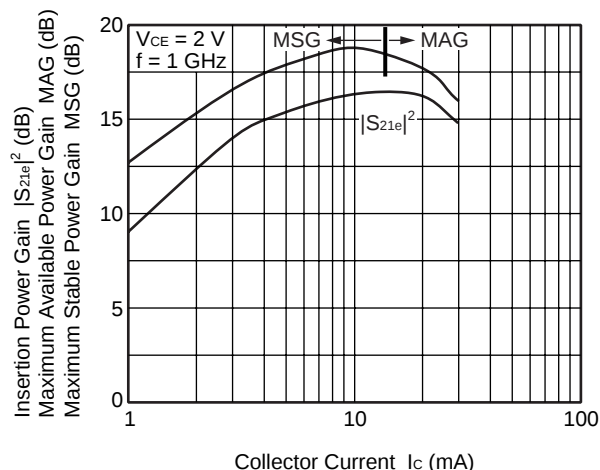
INSERTION POWER GAIN vs. FREQUENCY



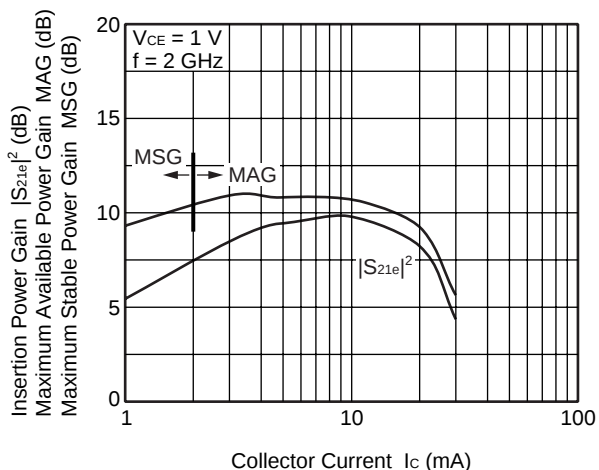
INSERTION POWER GAIN, MAG, MSG  
vs. COLLECTOR CURRENT



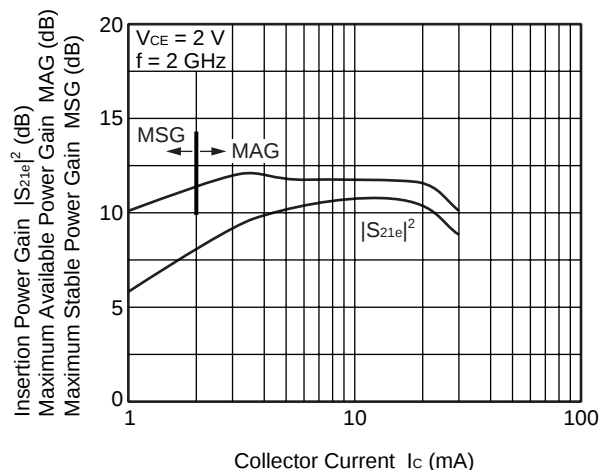
INSERTION POWER GAIN, MAG, MSG  
vs. COLLECTOR CURRENT



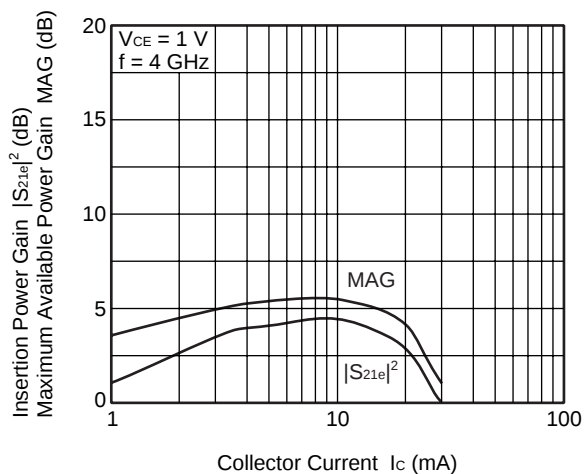
INSERTION POWER GAIN, MAG, MSG  
vs. COLLECTOR CURRENT



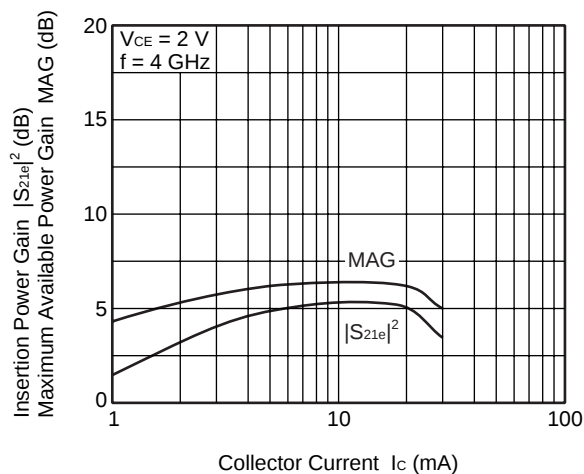
INSERTION POWER GAIN, MAG, MSG  
vs. COLLECTOR CURRENT



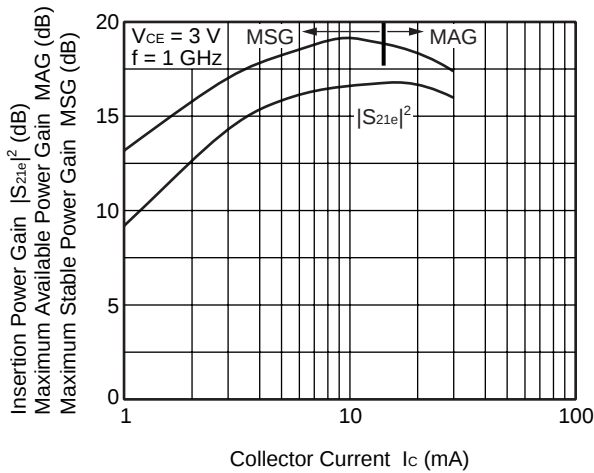
INSERTION POWER GAIN, MAG  
vs. COLLECTOR CURRENT



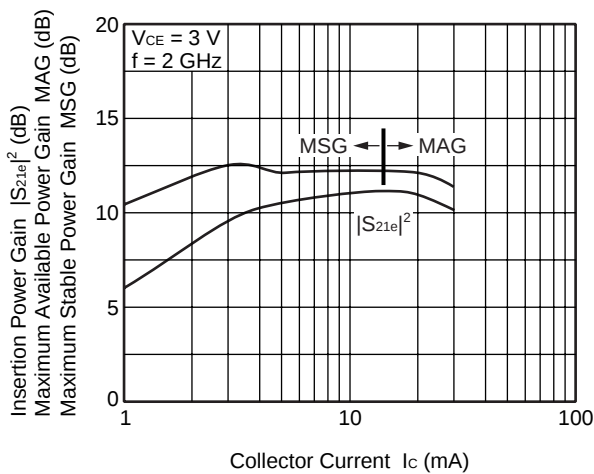
INSERTION POWER GAIN, MAG  
vs. COLLECTOR CURRENT



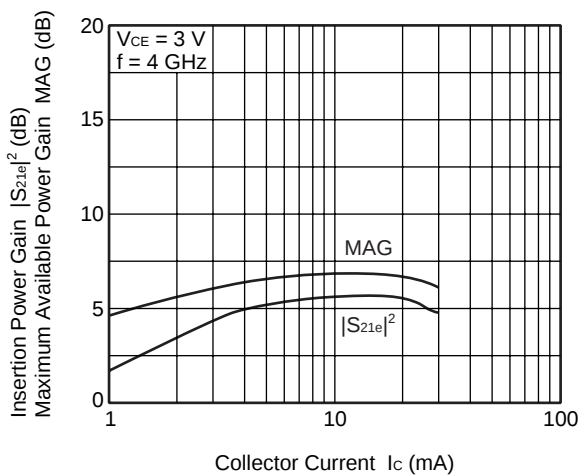
INSERTION POWER GAIN, MAG, MSG  
vs. COLLECTOR CURRENT



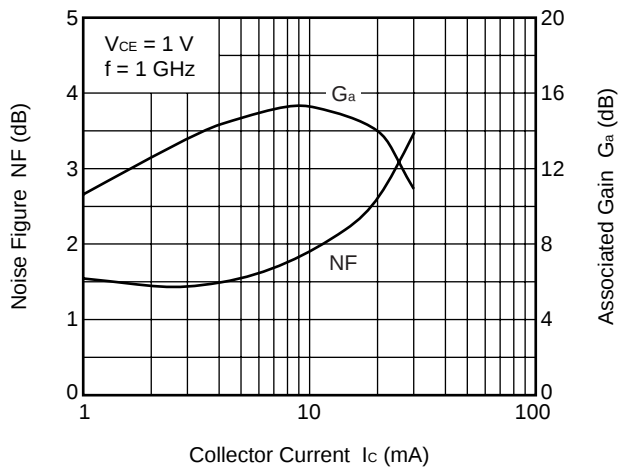
INSERTION POWER GAIN, MAG, MSG  
vs. COLLECTOR CURRENT



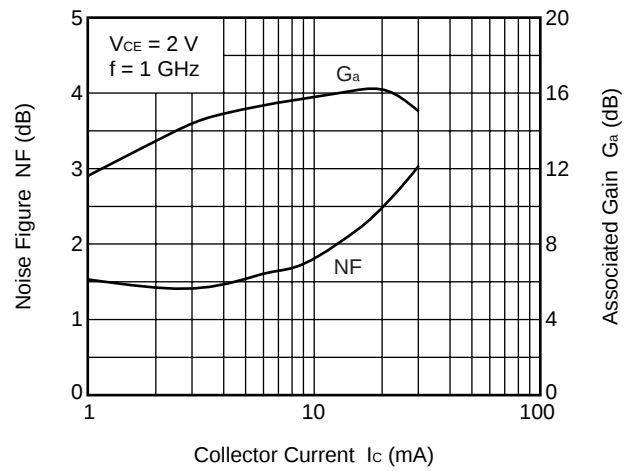
INSERTION POWER GAIN, MAG  
vs. COLLECTOR CURRENT



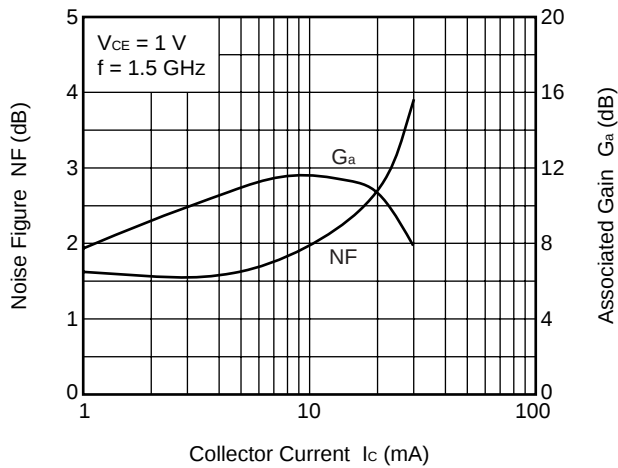
NOISE FIGURE, ASSOCIATED GAIN  
vs. COLLECTOR CURRENT



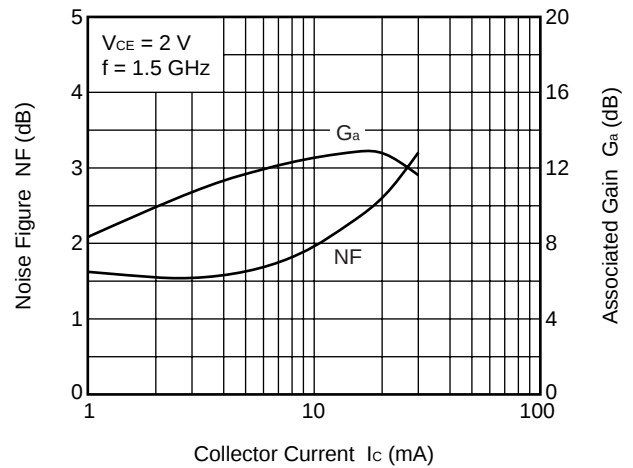
NOISE FIGURE, ASSOCIATED GAIN  
vs. COLLECTOR CURRENT



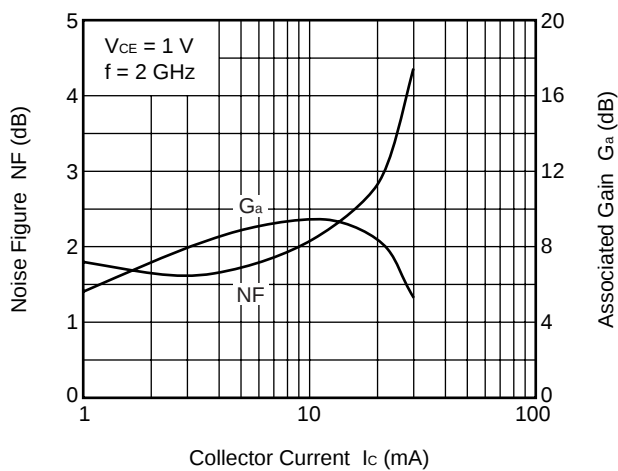
NOISE FIGURE, ASSOCIATED GAIN  
vs. COLLECTOR CURRENT



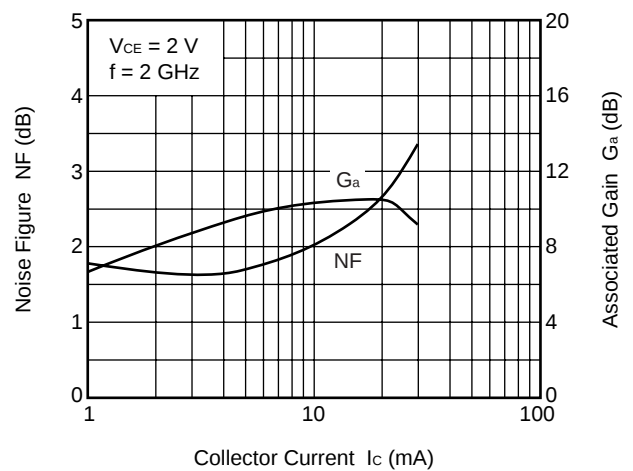
NOISE FIGURE, ASSOCIATED GAIN  
vs. COLLECTOR CURRENT



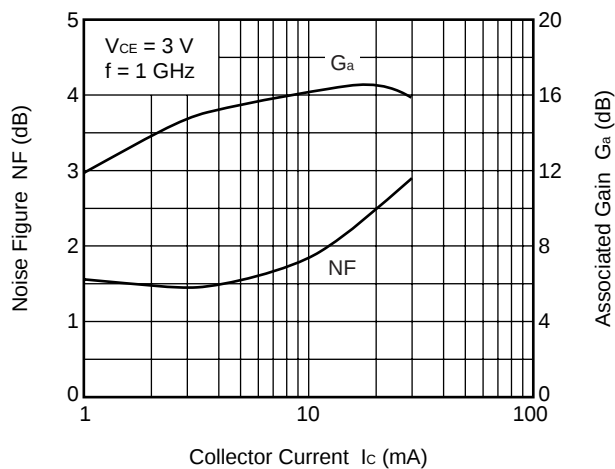
NOISE FIGURE, ASSOCIATED GAIN  
vs. COLLECTOR CURRENT



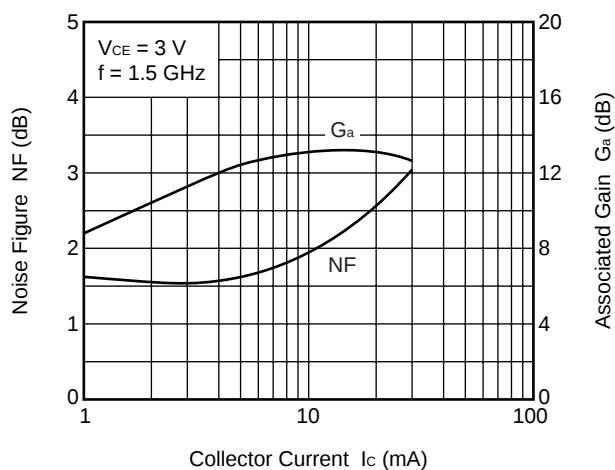
NOISE FIGURE, ASSOCIATED GAIN  
vs. COLLECTOR CURRENT



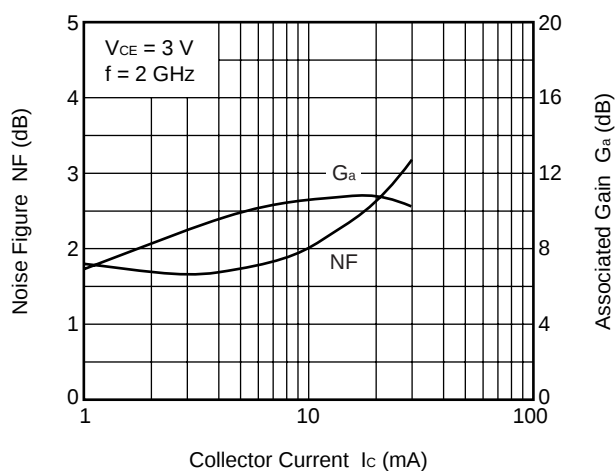
NOISE FIGURE, ASSOCIATED GAIN  
vs. COLLECTOR CURRENT



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                | 0.964           | -8.2           | 3.547           | 172.1          | 0.020           | 85.4           | 1.001           | -3.6           |
| 0.2                | 0.963           | -13.8          | 3.472           | 166.9          | 0.044           | 80.7           | 0.989           | -7.7           |
| 0.3                | 0.927           | -21.7          | 3.383           | 160.6          | 0.065           | 76.5           | 0.980           | -11.3          |
| 0.4                | 0.917           | -29.2          | 3.345           | 153.5          | 0.086           | 71.9           | 0.957           | -15.4          |
| 0.5                | 0.892           | -36.1          | 3.309           | 147.5          | 0.105           | 67.5           | 0.940           | -18.8          |
| 0.6                | 0.850           | -42.9          | 3.189           | 140.7          | 0.122           | 63.1           | 0.901           | -22.7          |
| 0.7                | 0.816           | -49.8          | 3.106           | 135.3          | 0.137           | 59.5           | 0.877           | -26.0          |
| 0.8                | 0.772           | -56.2          | 2.997           | 129.2          | 0.150           | 55.7           | 0.837           | -29.1          |
| 0.9                | 0.730           | -62.8          | 2.874           | 124.4          | 0.162           | 52.4           | 0.806           | -32.3          |
| 1.0                | 0.694           | -69.1          | 2.768           | 119.4          | 0.171           | 49.5           | 0.767           | -35.1          |
| 1.1                | 0.659           | -75.6          | 2.660           | 114.3          | 0.180           | 46.6           | 0.744           | -37.9          |
| 1.2                | 0.626           | -81.9          | 2.567           | 109.7          | 0.187           | 44.4           | 0.710           | -40.3          |
| 1.3                | 0.596           | -88.0          | 2.452           | 105.3          | 0.194           | 41.6           | 0.692           | -42.7          |
| 1.4                | 0.563           | -94.2          | 2.363           | 100.6          | 0.199           | 39.4           | 0.662           | -44.8          |
| 1.5                | 0.535           | -100.1         | 2.262           | 97.1           | 0.204           | 37.6           | 0.645           | -46.9          |
| 1.6                | 0.510           | -105.4         | 2.174           | 93.1           | 0.207           | 35.6           | 0.618           | -48.7          |
| 1.7                | 0.492           | -111.3         | 2.101           | 89.8           | 0.210           | 34.0           | 0.601           | -50.6          |
| 1.8                | 0.464           | -117.4         | 2.017           | 85.8           | 0.212           | 32.6           | 0.578           | -51.8          |
| 1.9                | 0.449           | -121.8         | 1.942           | 83.1           | 0.214           | 31.4           | 0.562           | -53.6          |
| 2.0                | 0.440           | -127.9         | 1.868           | 79.7           | 0.215           | 30.6           | 0.541           | -54.7          |
| 2.1                | 0.432           | -133.4         | 1.812           | 77.0           | 0.216           | 29.8           | 0.528           | -56.6          |
| 2.2                | 0.423           | -137.8         | 1.761           | 74.5           | 0.217           | 29.1           | 0.512           | -57.6          |
| 2.3                | 0.418           | -142.5         | 1.701           | 71.6           | 0.218           | 28.5           | 0.505           | -59.4          |
| 2.4                | 0.411           | -147.8         | 1.658           | 69.5           | 0.217           | 27.9           | 0.491           | -60.6          |
| 2.5                | 0.407           | -152.5         | 1.599           | 67.1           | 0.218           | 27.5           | 0.485           | -62.4          |
| 2.6                | 0.404           | -157.0         | 1.557           | 64.2           | 0.218           | 26.0           | 0.479           | -64.0          |
| 2.7                | 0.402           | -160.4         | 1.522           | 62.1           | 0.219           | 25.8           | 0.472           | -65.5          |
| 2.8                | 0.401           | -164.5         | 1.472           | 59.5           | 0.219           | 25.2           | 0.466           | -66.4          |
| 2.9                | 0.398           | -167.8         | 1.433           | 57.6           | 0.221           | 25.7           | 0.457           | -67.6          |
| 3.0                | 0.394           | -171.9         | 1.397           | 55.6           | 0.221           | 25.7           | 0.446           | -68.5          |
| 4.0                | 0.419           | 154.7          | 1.130           | 36.6           | 0.233           | 29.7           | 0.394           | -84.1          |
| 5.0                | 0.505           | 131.9          | 0.967           | 21.4           | 0.272           | 32.6           | 0.336           | -104.3         |

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

| 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                | 0.888           | -13.1          | 9.320           | 167.8          | 0.021           | 82.3           | 0.983           | -7.9           |
| 0.2                | 0.866           | -24.8          | 8.902           | 158.1          | 0.042           | 75.9           | 0.944           | -15.5          |
| 0.3                | 0.793           | -36.8          | 8.328           | 148.7          | 0.059           | 69.9           | 0.899           | -22.2          |
| 0.4                | 0.748           | -48.2          | 7.822           | 139.3          | 0.074           | 64.6           | 0.833           | -28.5          |
| 0.5                | 0.687           | -58.5          | 7.307           | 131.4          | 0.087           | 59.9           | 0.776           | -33.4          |
| 0.6                | 0.620           | -67.3          | 6.668           | 124.0          | 0.097           | 56.4           | 0.704           | -37.9          |
| 0.7                | 0.562           | -76.1          | 6.174           | 118.3          | 0.106           | 54.0           | 0.654           | -41.2          |
| 0.8                | 0.511           | -83.9          | 5.668           | 112.4          | 0.112           | 51.8           | 0.599           | -44.5          |
| 0.9                | 0.469           | -92.0          | 5.229           | 108.0          | 0.119           | 50.1           | 0.557           | -47.2          |
| 1.0                | 0.433           | -99.6          | 4.845           | 103.6          | 0.124           | 49.1           | 0.513           | -49.6          |
| 1.1                | 0.402           | -107.2         | 4.508           | 99.5           | 0.130           | 48.1           | 0.485           | -51.8          |
| 1.2                | 0.381           | -114.2         | 4.235           | 95.7           | 0.135           | 47.7           | 0.452           | -54.0          |
| 1.3                | 0.361           | -121.1         | 3.952           | 92.4           | 0.139           | 46.7           | 0.433           | -55.8          |
| 1.4                | 0.341           | -128.2         | 3.712           | 88.9           | 0.144           | 46.3           | 0.407           | -57.3          |
| 1.5                | 0.327           | -134.5         | 3.500           | 86.1           | 0.149           | 46.1           | 0.394           | -58.7          |
| 1.6                | 0.315           | -141.2         | 3.303           | 83.1           | 0.153           | 45.8           | 0.369           | -60.0          |
| 1.7                | 0.310           | -147.4         | 3.141           | 80.8           | 0.157           | 45.5           | 0.358           | -61.4          |
| 1.8                | 0.299           | -154.1         | 2.987           | 77.8           | 0.161           | 45.4           | 0.338           | -62.2          |
| 1.9                | 0.293           | -157.6         | 2.856           | 75.7           | 0.166           | 45.4           | 0.327           | -63.8          |
| 2.0                | 0.301           | -163.5         | 2.713           | 73.2           | 0.170           | 45.4           | 0.311           | -64.6          |
| 2.1                | 0.301           | -168.4         | 2.607           | 71.1           | 0.175           | 45.3           | 0.302           | -66.6          |
| 2.2                | 0.305           | -171.6         | 2.518           | 69.2           | 0.179           | 45.4           | 0.290           | -67.4          |
| 2.3                | 0.304           | -175.5         | 2.422           | 66.8           | 0.184           | 45.3           | 0.284           | -69.5          |
| 2.4                | 0.306           | -179.7         | 2.340           | 65.4           | 0.188           | 45.1           | 0.275           | -70.3          |
| 2.5                | 0.311           | 176.9          | 2.242           | 63.6           | 0.192           | 45.0           | 0.270           | -72.4          |
| 2.6                | 0.316           | 172.8          | 2.172           | 61.3           | 0.197           | 44.4           | 0.265           | -73.4          |
| 2.7                | 0.316           | 170.3          | 2.115           | 59.6           | 0.201           | 44.2           | 0.260           | -75.2          |
| 2.8                | 0.320           | 166.7          | 2.042           | 57.6           | 0.206           | 43.8           | 0.255           | -75.5          |
| 2.9                | 0.322           | 165.0          | 1.983           | 56.2           | 0.213           | 44.1           | 0.248           | -77.3          |
| 3.0                | 0.323           | 161.5          | 1.921           | 54.6           | 0.217           | 43.9           | 0.240           | -77.7          |
| 4.0                | 0.375           | 138.2          | 1.502           | 38.4           | 0.267           | 42.2           | 0.201           | -98.0          |
| 5.0                | 0.462           | 122.9          | 1.271           | 24.6           | 0.322           | 37.0           | 0.143           | -127.5         |

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

| 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                | 0.814           | -17.2          | 13.888          | 164.3          | 0.019           | 79.7           | 0.964           | -11.3          |
| 0.2                | 0.771           | -33.4          | 12.825          | 151.4          | 0.039           | 72.2           | 0.895           | -21.4          |
| 0.3                | 0.678           | -48.5          | 11.484          | 140.3          | 0.053           | 66.4           | 0.816           | -29.6          |
| 0.4                | 0.613           | -61.4          | 10.318          | 130.0          | 0.065           | 61.7           | 0.726           | -36.2          |
| 0.5                | 0.547           | -73.3          | 9.258           | 121.9          | 0.075           | 58.2           | 0.651           | -40.9          |
| 0.6                | 0.477           | -83.0          | 8.201           | 115.0          | 0.083           | 56.1           | 0.575           | -44.9          |
| 0.7                | 0.426           | -92.5          | 7.406           | 109.6          | 0.089           | 55.1           | 0.523           | -47.7          |
| 0.8                | 0.385           | -100.9         | 6.680           | 104.5          | 0.095           | 54.1           | 0.469           | -50.3          |
| 0.9                | 0.350           | -110.0         | 6.061           | 100.7          | 0.101           | 53.5           | 0.433           | -52.4          |
| 1.0                | 0.329           | -117.6         | 5.557           | 96.9           | 0.107           | 53.3           | 0.395           | -54.5          |
| 1.1                | 0.309           | -125.9         | 5.102           | 93.4           | 0.113           | 53.4           | 0.372           | -56.4          |
| 1.2                | 0.295           | -133.7         | 4.743           | 90.1           | 0.118           | 53.4           | 0.345           | -58.3          |
| 1.3                | 0.286           | -140.1         | 4.409           | 87.1           | 0.124           | 53.0           | 0.330           | -59.8          |
| 1.4                | 0.278           | -147.2         | 4.111           | 84.2           | 0.130           | 53.0           | 0.308           | -61.3          |
| 1.5                | 0.270           | -153.8         | 3.873           | 81.9           | 0.136           | 53.0           | 0.298           | -62.4          |
| 1.6                | 0.266           | -160.6         | 3.639           | 79.3           | 0.141           | 52.9           | 0.279           | -63.6          |
| 1.7                | 0.270           | -165.8         | 3.452           | 77.2           | 0.147           | 52.8           | 0.270           | -65.0          |
| 1.8                | 0.266           | -172.2         | 3.272           | 74.7           | 0.152           | 52.8           | 0.253           | -65.8          |
| 1.9                | 0.263           | -175.7         | 3.122           | 72.9           | 0.158           | 52.7           | 0.245           | -67.5          |
| 2.0                | 0.275           | -179.7         | 2.964           | 70.6           | 0.164           | 52.6           | 0.231           | -68.4          |
| 2.1                | 0.280           | 176.3          | 2.839           | 68.7           | 0.170           | 52.4           | 0.226           | -70.8          |
| 2.2                | 0.285           | 173.2          | 2.738           | 67.1           | 0.176           | 52.3           | 0.215           | -71.6          |
| 2.3                | 0.285           | 170.8          | 2.634           | 64.9           | 0.182           | 52.0           | 0.211           | -74.1          |
| 2.4                | 0.290           | 166.7          | 2.541           | 63.6           | 0.187           | 51.7           | 0.203           | -75.0          |
| 2.5                | 0.298           | 164.2          | 2.431           | 62.0           | 0.193           | 51.4           | 0.200           | -77.7          |
| 2.6                | 0.304           | 161.1          | 2.347           | 59.9           | 0.198           | 50.6           | 0.195           | -78.6          |
| 2.7                | 0.306           | 159.0          | 2.286           | 58.4           | 0.204           | 50.4           | 0.191           | -80.7          |
| 2.8                | 0.312           | 156.5          | 2.209           | 56.6           | 0.210           | 49.6           | 0.187           | -81.0          |
| 2.9                | 0.314           | 155.0          | 2.145           | 55.2           | 0.217           | 49.6           | 0.183           | -83.2          |
| 3.0                | 0.317           | 151.9          | 2.072           | 53.8           | 0.222           | 49.3           | 0.175           | -83.6          |
| 4.0                | 0.367           | 132.6          | 1.611           | 38.7           | 0.280           | 45.2           | 0.147           | -109.7         |
| 5.0                | 0.457           | 119.8          | 1.360           | 25.4           | 0.336           | 38.1           | 0.106           | -153.3         |

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

| 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                | 0.745           | -21.4          | 17.422          | 161.3          | 0.019           | 78.1           | 0.943           | -13.9          |
| 0.2                | 0.688           | -40.0          | 15.581          | 146.1          | 0.036           | 70.2           | 0.848           | -25.8          |
| 0.3                | 0.587           | -57.3          | 13.483          | 134.3          | 0.049           | 64.6           | 0.747           | -34.4          |
| 0.4                | 0.519           | -71.2          | 11.713          | 123.9          | 0.059           | 60.9           | 0.646           | -40.8          |
| 0.5                | 0.457           | -83.7          | 10.251          | 116.0          | 0.067           | 58.6           | 0.569           | -44.9          |
| 0.6                | 0.392           | -94.5          | 8.924           | 109.7          | 0.074           | 57.4           | 0.495           | -48.3          |
| 0.7                | 0.353           | -104.1         | 7.948           | 104.8          | 0.081           | 57.4           | 0.446           | -50.6          |
| 0.8                | 0.317           | -113.8         | 7.110           | 100.0          | 0.086           | 57.1           | 0.397           | -52.7          |
| 0.9                | 0.297           | -123.2         | 6.421           | 96.6           | 0.093           | 56.8           | 0.365           | -54.5          |
| 1.0                | 0.282           | -131.2         | 5.848           | 93.3           | 0.099           | 57.0           | 0.332           | -56.3          |
| 1.1                | 0.268           | -139.3         | 5.346           | 90.0           | 0.106           | 57.2           | 0.312           | -58.0          |
| 1.2                | 0.262           | -146.9         | 4.956           | 87.1           | 0.112           | 57.5           | 0.289           | -59.8          |
| 1.3                | 0.260           | -153.3         | 4.577           | 84.6           | 0.118           | 57.2           | 0.277           | -61.1          |
| 1.4                | 0.257           | -160.2         | 4.271           | 81.7           | 0.124           | 57.2           | 0.258           | -62.6          |
| 1.5                | 0.255           | -166.1         | 4.020           | 79.7           | 0.131           | 57.2           | 0.251           | -63.7          |
| 1.6                | 0.254           | -172.4         | 3.771           | 77.2           | 0.138           | 57.1           | 0.234           | -65.0          |
| 1.7                | 0.261           | -176.6         | 3.570           | 75.4           | 0.144           | 56.9           | 0.227           | -66.3          |
| 1.8                | 0.260           | 177.5          | 3.385           | 73.0           | 0.150           | 56.8           | 0.211           | -67.3          |
| 1.9                | 0.259           | 174.3          | 3.233           | 71.3           | 0.156           | 56.5           | 0.206           | -69.1          |
| 2.0                | 0.271           | 171.1          | 3.058           | 69.2           | 0.163           | 56.3           | 0.193           | -70.1          |
| 2.1                | 0.277           | 168.3          | 2.930           | 67.4           | 0.169           | 55.9           | 0.189           | -73.0          |
| 2.2                | 0.281           | 165.6          | 2.824           | 65.8           | 0.176           | 55.8           | 0.179           | -73.9          |
| 2.3                | 0.285           | 163.0          | 2.712           | 63.7           | 0.182           | 55.3           | 0.176           | -76.8          |
| 2.4                | 0.291           | 159.9          | 2.619           | 62.7           | 0.188           | 54.9           | 0.170           | -77.6          |
| 2.5                | 0.297           | 157.5          | 2.503           | 61.1           | 0.194           | 54.5           | 0.167           | -80.7          |
| 2.6                | 0.304           | 154.7          | 2.419           | 59.0           | 0.200           | 53.7           | 0.163           | -81.7          |
| 2.7                | 0.307           | 153.3          | 2.353           | 57.5           | 0.206           | 53.2           | 0.160           | -84.2          |
| 2.8                | 0.312           | 150.4          | 2.271           | 56.0           | 0.213           | 52.3           | 0.156           | -84.4          |
| 2.9                | 0.314           | 149.3          | 2.205           | 54.6           | 0.220           | 52.2           | 0.152           | -87.1          |
| 3.0                | 0.317           | 146.7          | 2.132           | 53.2           | 0.226           | 51.6           | 0.145           | -87.6          |
| 4.0                | 0.370           | 129.5          | 1.650           | 38.6           | 0.285           | 46.5           | 0.126           | -118.2         |
| 5.0                | 0.458           | 118.1          | 1.386           | 25.7           | 0.343           | 38.6           | 0.100           | -169.8         |

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

| 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                | 0.672           | -27.5          | 21.337          | 157.6          | 0.018           | 76.7           | 0.912           | -17.1          |
| 0.2                | 0.597           | -49.5          | 18.295          | 140.2          | 0.033           | 68.3           | 0.786           | -30.4          |
| 0.3                | 0.486           | -68.7          | 15.148          | 127.9          | 0.044           | 64.0           | 0.666           | -38.9          |
| 0.4                | 0.423           | -83.6          | 12.748          | 117.8          | 0.053           | 61.6           | 0.560           | -44.6          |
| 0.5                | 0.373           | -97.0          | 10.899          | 110.4          | 0.060           | 60.3           | 0.486           | -47.8          |
| 0.6                | 0.322           | -108.3         | 9.366           | 104.6          | 0.067           | 59.9           | 0.419           | -50.4          |
| 0.7                | 0.292           | -118.5         | 8.258           | 100.5          | 0.074           | 60.3           | 0.376           | -51.8          |
| 0.8                | 0.268           | -129.1         | 7.332           | 96.1           | 0.080           | 60.5           | 0.333           | -53.5          |
| 0.9                | 0.258           | -138.4         | 6.599           | 93.1           | 0.087           | 60.7           | 0.305           | -54.9          |
| 1.0                | 0.252           | -146.3         | 5.976           | 90.0           | 0.094           | 60.9           | 0.278           | -56.6          |
| 1.1                | 0.247           | -154.0         | 5.454           | 87.2           | 0.101           | 61.2           | 0.262           | -58.0          |
| 1.2                | 0.245           | -160.5         | 5.049           | 84.5           | 0.108           | 61.4           | 0.242           | -59.7          |
| 1.3                | 0.247           | -166.5         | 4.668           | 82.2           | 0.115           | 61.1           | 0.234           | -61.1          |
| 1.4                | 0.249           | -172.4         | 4.338           | 79.6           | 0.121           | 61.0           | 0.218           | -62.5          |
| 1.5                | 0.252           | -177.6         | 4.078           | 77.6           | 0.128           | 60.8           | 0.213           | -63.7          |
| 1.6                | 0.254           | 177.3          | 3.822           | 75.3           | 0.135           | 60.8           | 0.197           | -64.9          |
| 1.7                | 0.263           | 173.6          | 3.612           | 73.5           | 0.142           | 60.4           | 0.193           | -66.4          |
| 1.8                | 0.265           | 167.9          | 3.425           | 71.4           | 0.149           | 60.1           | 0.179           | -67.5          |
| 1.9                | 0.262           | 165.7          | 3.267           | 69.8           | 0.155           | 59.7           | 0.174           | -69.6          |
| 2.0                | 0.276           | 163.3          | 3.085           | 67.7           | 0.162           | 59.4           | 0.162           | -70.5          |
| 2.1                | 0.285           | 160.9          | 2.957           | 66.0           | 0.169           | 58.9           | 0.160           | -73.9          |
| 2.2                | 0.289           | 158.6          | 2.856           | 64.7           | 0.176           | 58.5           | 0.151           | -74.9          |
| 2.3                | 0.291           | 156.6          | 2.739           | 62.5           | 0.183           | 58.0           | 0.149           | -78.3          |
| 2.4                | 0.297           | 154.3          | 2.643           | 61.5           | 0.189           | 57.4           | 0.144           | -79.3          |
| 2.5                | 0.304           | 152.1          | 2.527           | 60.0           | 0.196           | 57.0           | 0.142           | -83.0          |
| 2.6                | 0.311           | 149.8          | 2.440           | 58.0           | 0.202           | 56.1           | 0.138           | -84.0          |
| 2.7                | 0.314           | 148.3          | 2.375           | 56.7           | 0.208           | 55.5           | 0.136           | -86.8          |
| 2.8                | 0.320           | 146.1          | 2.293           | 55.1           | 0.215           | 54.6           | 0.132           | -87.1          |
| 2.9                | 0.321           | 144.8          | 2.223           | 53.9           | 0.223           | 54.3           | 0.129           | -90.2          |
| 3.0                | 0.323           | 142.6          | 2.152           | 52.5           | 0.229           | 53.7           | 0.123           | -90.8          |
| 4.0                | 0.376           | 127.4          | 1.658           | 38.1           | 0.290           | 47.7           | 0.112           | -125.9         |
| 5.0                | 0.463           | 116.4          | 1.398           | 25.6           | 0.348           | 39.2           | 0.101           | 178.4          |

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

| 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                | 0.458           | -47.7          | 25.447          | 148.0          | 0.017           | 72.5           | 0.781           | -24.4          |
| 0.2                | 0.404           | -79.8          | 19.296          | 127.1          | 0.028           | 65.3           | 0.600           | -38.1          |
| 0.3                | 0.331           | -105.4         | 14.700          | 115.4          | 0.037           | 63.5           | 0.476           | -43.8          |
| 0.4                | 0.311           | -122.2         | 11.737          | 106.8          | 0.044           | 63.8           | 0.389           | -46.4          |
| 0.5                | 0.297           | -135.9         | 9.706           | 100.7          | 0.052           | 64.1           | 0.337           | -46.8          |
| 0.6                | 0.281           | -147.1         | 8.204           | 96.0           | 0.059           | 64.8           | 0.290           | -47.4          |
| 0.7                | 0.276           | -156.5         | 7.162           | 92.6           | 0.066           | 65.7           | 0.263           | -47.1          |
| 0.8                | 0.275           | -164.4         | 6.307           | 89.0           | 0.073           | 66.1           | 0.235           | -47.6          |
| 0.9                | 0.280           | -171.3         | 5.635           | 86.5           | 0.081           | 66.4           | 0.219           | -48.3          |
| 1.0                | 0.286           | -176.6         | 5.089           | 83.9           | 0.088           | 66.5           | 0.200           | -49.6          |
| 1.1                | 0.288           | 178.5          | 4.624           | 81.4           | 0.096           | 66.6           | 0.193           | -51.0          |
| 1.2                | 0.295           | 174.4          | 4.267           | 79.1           | 0.103           | 66.6           | 0.179           | -52.7          |
| 1.3                | 0.299           | 170.8          | 3.953           | 77.0           | 0.111           | 66.1           | 0.176           | -54.4          |
| 1.4                | 0.306           | 167.2          | 3.671           | 74.6           | 0.118           | 65.9           | 0.165           | -55.8          |
| 1.5                | 0.311           | 164.0          | 3.442           | 72.9           | 0.125           | 65.7           | 0.164           | -57.2          |
| 1.6                | 0.316           | 160.1          | 3.222           | 70.7           | 0.133           | 65.3           | 0.153           | -58.4          |
| 1.7                | 0.326           | 158.4          | 3.046           | 69.2           | 0.140           | 64.7           | 0.152           | -60.5          |
| 1.8                | 0.331           | 154.5          | 2.886           | 67.0           | 0.147           | 64.3           | 0.140           | -61.5          |
| 1.9                | 0.330           | 152.6          | 2.755           | 65.4           | 0.154           | 63.9           | 0.139           | -64.4          |
| 2.0                | 0.341           | 151.0          | 2.604           | 63.5           | 0.162           | 63.3           | 0.129           | -65.5          |
| 2.1                | 0.350           | 149.8          | 2.493           | 61.8           | 0.169           | 62.6           | 0.129           | -69.9          |
| 2.2                | 0.351           | 148.3          | 2.409           | 60.5           | 0.176           | 62.1           | 0.122           | -71.1          |
| 2.3                | 0.353           | 146.4          | 2.312           | 58.4           | 0.183           | 61.4           | 0.121           | -75.5          |
| 2.4                | 0.361           | 144.5          | 2.232           | 57.5           | 0.190           | 60.8           | 0.117           | -76.7          |
| 2.5                | 0.367           | 143.1          | 2.135           | 56.1           | 0.197           | 60.2           | 0.117           | -81.5          |
| 2.6                | 0.376           | 141.5          | 2.061           | 54.2           | 0.204           | 59.2           | 0.115           | -82.6          |
| 2.7                | 0.376           | 140.0          | 2.008           | 52.8           | 0.210           | 58.4           | 0.114           | -86.4          |
| 2.8                | 0.384           | 138.3          | 1.941           | 51.2           | 0.217           | 57.4           | 0.112           | -87.0          |
| 2.9                | 0.384           | 137.5          | 1.885           | 50.1           | 0.225           | 57.0           | 0.110           | -91.1          |
| 3.0                | 0.387           | 135.3          | 1.822           | 48.7           | 0.231           | 56.3           | 0.105           | -92.1          |
| 4.0                | 0.431           | 121.9          | 1.406           | 34.8           | 0.295           | 49.6           | 0.106           | -131.7         |
| 5.0                | 0.511           | 112.0          | 1.192           | 22.6           | 0.355           | 40.6           | 0.112           | 173.9          |

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

| 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                | 0.965           | -6.9           | 3.517           | 172.7          | 0.018           | 87.1           | 1.004           | -3.0           |
| 0.2                | 0.967           | -12.6          | 3.451           | 167.9          | 0.037           | 82.2           | 0.992           | -6.4           |
| 0.3                | 0.932           | -19.9          | 3.375           | 161.9          | 0.055           | 77.5           | 0.987           | -9.4           |
| 0.4                | 0.927           | -26.9          | 3.346           | 155.4          | 0.073           | 73.7           | 0.967           | -13.0          |
| 0.5                | 0.903           | -33.0          | 3.318           | 149.7          | 0.090           | 69.7           | 0.956           | -16.0          |
| 0.6                | 0.866           | -39.5          | 3.211           | 143.2          | 0.105           | 65.4           | 0.921           | -19.3          |
| 0.7                | 0.829           | -45.9          | 3.141           | 138.2          | 0.118           | 62.3           | 0.901           | -22.2          |
| 0.8                | 0.794           | -51.8          | 3.041           | 132.3          | 0.130           | 58.7           | 0.865           | -25.1          |
| 0.9                | 0.750           | -57.9          | 2.924           | 127.7          | 0.141           | 55.5           | 0.839           | -27.7          |
| 1.0                | 0.718           | -64.0          | 2.832           | 122.8          | 0.149           | 52.7           | 0.803           | -30.2          |
| 1.1                | 0.681           | -70.2          | 2.733           | 117.7          | 0.158           | 49.9           | 0.782           | -32.8          |
| 1.2                | 0.648           | -76.1          | 2.655           | 113.3          | 0.165           | 47.8           | 0.752           | -35.0          |
| 1.3                | 0.618           | -82.1          | 2.538           | 108.9          | 0.171           | 45.0           | 0.736           | -37.2          |
| 1.4                | 0.585           | -87.7          | 2.450           | 104.4          | 0.176           | 42.9           | 0.709           | -39.1          |
| 1.5                | 0.552           | -93.3          | 2.356           | 100.7          | 0.182           | 41.2           | 0.693           | -41.0          |
| 1.6                | 0.525           | -98.8          | 2.268           | 96.7           | 0.185           | 39.2           | 0.667           | -42.6          |
| 1.7                | 0.504           | -104.5         | 2.193           | 93.5           | 0.188           | 37.8           | 0.651           | -44.4          |
| 1.8                | 0.475           | -109.8         | 2.110           | 89.5           | 0.190           | 36.4           | 0.628           | -45.6          |
| 1.9                | 0.457           | -114.1         | 2.034           | 86.8           | 0.192           | 35.2           | 0.613           | -47.1          |
| 2.0                | 0.449           | -120.6         | 1.958           | 83.5           | 0.193           | 34.5           | 0.593           | -48.1          |
| 2.1                | 0.438           | -125.9         | 1.901           | 80.8           | 0.195           | 33.7           | 0.581           | -49.6          |
| 2.2                | 0.429           | -130.3         | 1.853           | 78.1           | 0.196           | 33.0           | 0.566           | -50.8          |
| 2.3                | 0.417           | -135.1         | 1.791           | 75.3           | 0.197           | 32.5           | 0.558           | -52.3          |
| 2.4                | 0.408           | -140.3         | 1.742           | 73.2           | 0.197           | 31.9           | 0.545           | -53.4          |
| 2.5                | 0.401           | -145.1         | 1.680           | 70.7           | 0.197           | 31.5           | 0.538           | -55.0          |
| 2.6                | 0.397           | -149.7         | 1.637           | 67.8           | 0.198           | 30.2           | 0.534           | -56.6          |
| 2.7                | 0.394           | -153.5         | 1.601           | 65.8           | 0.199           | 30.0           | 0.527           | -57.9          |
| 2.8                | 0.391           | -158.0         | 1.550           | 63.3           | 0.200           | 29.5           | 0.522           | -58.7          |
| 2.9                | 0.387           | -161.3         | 1.509           | 61.2           | 0.202           | 30.0           | 0.511           | -59.8          |
| 3.0                | 0.380           | -165.1         | 1.470           | 59.3           | 0.202           | 30.2           | 0.502           | -60.6          |
| 4.0                | 0.398           | 158.8          | 1.191           | 40.2           | 0.217           | 35.0           | 0.448           | -74.4          |
| 5.0                | 0.481           | 134.6          | 1.019           | 24.6           | 0.259           | 38.6           | 0.389           | -91.1          |

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

| 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                | 0.888           | -12.0          | 9.332           | 168.8          | 0.017           | 84.2           | 0.989           | -6.5           |
| 0.2                | 0.876           | -22.0          | 8.935           | 159.7          | 0.035           | 77.8           | 0.956           | -12.9          |
| 0.3                | 0.810           | -32.9          | 8.423           | 150.8          | 0.050           | 72.0           | 0.918           | -18.5          |
| 0.4                | 0.769           | -43.3          | 7.967           | 141.8          | 0.064           | 67.3           | 0.863           | -23.9          |
| 0.5                | 0.711           | -52.7          | 7.521           | 134.3          | 0.076           | 62.8           | 0.814           | -28.0          |
| 0.6                | 0.645           | -61.0          | 6.912           | 127.0          | 0.085           | 59.4           | 0.749           | -31.9          |
| 0.7                | 0.590           | -69.0          | 6.446           | 121.4          | 0.093           | 57.2           | 0.704           | -34.8          |
| 0.8                | 0.532           | -76.0          | 5.953           | 115.5          | 0.099           | 54.9           | 0.649           | -37.4          |
| 0.9                | 0.485           | -83.5          | 5.512           | 111.1          | 0.106           | 53.3           | 0.612           | -39.8          |
| 1.0                | 0.450           | -90.4          | 5.133           | 106.8          | 0.111           | 52.2           | 0.569           | -41.6          |
| 1.1                | 0.414           | -97.2          | 4.785           | 102.5          | 0.116           | 51.3           | 0.543           | -43.5          |
| 1.2                | 0.385           | -104.0         | 4.497           | 98.7           | 0.121           | 50.9           | 0.511           | -45.1          |
| 1.3                | 0.363           | -110.5         | 4.214           | 95.4           | 0.126           | 49.9           | 0.492           | -46.7          |
| 1.4                | 0.337           | -117.4         | 3.968           | 91.8           | 0.130           | 49.5           | 0.467           | -47.8          |
| 1.5                | 0.320           | -123.7         | 3.751           | 89.0           | 0.135           | 49.2           | 0.454           | -49.1          |
| 1.6                | 0.302           | -130.3         | 3.542           | 86.0           | 0.139           | 48.9           | 0.431           | -49.9          |
| 1.7                | 0.296           | -136.4         | 3.373           | 83.6           | 0.143           | 48.7           | 0.420           | -51.2          |
| 1.8                | 0.281           | -143.1         | 3.207           | 80.6           | 0.147           | 48.7           | 0.400           | -51.6          |
| 1.9                | 0.271           | -146.7         | 3.065           | 78.5           | 0.152           | 48.5           | 0.389           | -52.9          |
| 2.0                | 0.274           | -153.4         | 2.917           | 76.0           | 0.156           | 48.6           | 0.373           | -53.3          |
| 2.1                | 0.276           | -158.4         | 2.804           | 73.9           | 0.160           | 48.6           | 0.364           | -54.9          |
| 2.2                | 0.276           | -162.3         | 2.705           | 72.0           | 0.164           | 48.5           | 0.353           | -55.4          |
| 2.3                | 0.273           | -166.7         | 2.604           | 69.7           | 0.169           | 48.5           | 0.347           | -57.0          |
| 2.4                | 0.274           | -171.6         | 2.517           | 68.3           | 0.173           | 48.4           | 0.338           | -57.6          |
| 2.5                | 0.276           | -175.5         | 2.414           | 66.3           | 0.177           | 48.4           | 0.332           | -59.4          |
| 2.6                | 0.281           | -179.8         | 2.336           | 64.0           | 0.182           | 47.6           | 0.328           | -60.2          |
| 2.7                | 0.281           | 177.6          | 2.277           | 62.4           | 0.186           | 47.6           | 0.322           | -61.6          |
| 2.8                | 0.286           | 173.6          | 2.197           | 60.4           | 0.191           | 47.2           | 0.319           | -61.9          |
| 2.9                | 0.286           | 171.2          | 2.131           | 58.9           | 0.197           | 47.4           | 0.311           | -63.1          |
| 3.0                | 0.287           | 167.5          | 2.065           | 57.4           | 0.201           | 47.4           | 0.304           | -63.4          |
| 4.0                | 0.336           | 142.0          | 1.614           | 41.3           | 0.250           | 46.2           | 0.258           | -79.2          |
| 5.0                | 0.426           | 125.5          | 1.369           | 27.4           | 0.305           | 41.6           | 0.188           | -96.7          |

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

| 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                | 0.836           | -15.2          | 13.930          | 165.3          | 0.015           | 80.7           | 0.974           | -9.2           |
| 0.2                | 0.788           | -29.2          | 12.973          | 153.4          | 0.033           | 74.3           | 0.916           | -17.7          |
| 0.3                | 0.702           | -42.7          | 11.773          | 142.8          | 0.046           | 69.1           | 0.850           | -24.5          |
| 0.4                | 0.639           | -54.5          | 10.712          | 132.8          | 0.057           | 64.7           | 0.769           | -30.1          |
| 0.5                | 0.571           | -65.4          | 9.705           | 124.8          | 0.066           | 61.1           | 0.703           | -34.0          |
| 0.6                | 0.498           | -73.7          | 8.665           | 117.9          | 0.073           | 59.1           | 0.631           | -37.4          |
| 0.7                | 0.445           | -82.6          | 7.862           | 112.7          | 0.080           | 58.0           | 0.582           | -39.5          |
| 0.8                | 0.394           | -90.1          | 7.132           | 107.3          | 0.085           | 57.0           | 0.531           | -41.4          |
| 0.9                | 0.357           | -98.1          | 6.497           | 103.4          | 0.091           | 56.4           | 0.495           | -43.2          |
| 1.0                | 0.329           | -105.5         | 5.969           | 99.7           | 0.097           | 56.1           | 0.457           | -44.5          |
| 1.1                | 0.302           | -113.1         | 5.499           | 96.2           | 0.102           | 56.2           | 0.434           | -45.8          |
| 1.2                | 0.285           | -120.6         | 5.126           | 92.7           | 0.107           | 56.2           | 0.409           | -47.0          |
| 1.3                | 0.269           | -127.4         | 4.757           | 90.0           | 0.113           | 55.7           | 0.394           | -48.2          |
| 1.4                | 0.255           | -135.0         | 4.450           | 86.7           | 0.118           | 55.7           | 0.373           | -49.0          |
| 1.5                | 0.246           | -141.6         | 4.195           | 84.5           | 0.124           | 55.9           | 0.364           | -50.0          |
| 1.6                | 0.237           | -148.9         | 3.947           | 81.8           | 0.129           | 55.7           | 0.344           | -50.7          |
| 1.7                | 0.239           | -154.5         | 3.743           | 79.8           | 0.134           | 55.6           | 0.336           | -51.7          |
| 1.8                | 0.230           | -161.8         | 3.552           | 77.2           | 0.140           | 55.5           | 0.319           | -52.0          |
| 1.9                | 0.225           | -165.6         | 3.393           | 75.4           | 0.145           | 55.4           | 0.311           | -53.2          |
| 2.0                | 0.236           | -171.3         | 3.215           | 73.2           | 0.151           | 55.4           | 0.298           | -53.5          |
| 2.1                | 0.240           | -174.5         | 3.085           | 71.2           | 0.156           | 55.2           | 0.291           | -55.4          |
| 2.2                | 0.243           | -178.8         | 2.977           | 69.7           | 0.162           | 55.2           | 0.281           | -55.6          |
| 2.3                | 0.244           | 178.4          | 2.857           | 67.5           | 0.167           | 54.9           | 0.276           | -57.5          |
| 2.4                | 0.247           | 174.1          | 2.758           | 66.3           | 0.172           | 54.7           | 0.269           | -58.0          |
| 2.5                | 0.253           | 170.3          | 2.642           | 64.6           | 0.178           | 54.5           | 0.264           | -60.0          |
| 2.6                | 0.259           | 166.9          | 2.549           | 62.5           | 0.183           | 53.6           | 0.261           | -60.7          |
| 2.7                | 0.261           | 164.7          | 2.483           | 61.0           | 0.189           | 53.4           | 0.256           | -62.2          |
| 2.8                | 0.267           | 161.4          | 2.395           | 59.3           | 0.194           | 52.7           | 0.253           | -62.3          |
| 2.9                | 0.268           | 159.8          | 2.324           | 57.9           | 0.201           | 52.7           | 0.247           | -63.7          |
| 3.0                | 0.269           | 156.3          | 2.247           | 56.4           | 0.206           | 52.5           | 0.240           | -63.9          |
| 4.0                | 0.325           | 135.4          | 1.745           | 41.6           | 0.262           | 49.0           | 0.200           | -82.4          |
| 5.0                | 0.416           | 122.5          | 1.474           | 28.4           | 0.319           | 42.6           | 0.128           | -104.0         |

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

| 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                | 0.767           | -19.5          | 17.533          | 162.8          | 0.016           | 78.0           | 0.958           | -11.3          |
| 0.2                | 0.722           | -34.9          | 15.888          | 148.6          | 0.031           | 72.4           | 0.878           | -21.2          |
| 0.3                | 0.618           | -50.2          | 13.968          | 137.2          | 0.042           | 67.8           | 0.792           | -28.3          |
| 0.4                | 0.543           | -62.8          | 12.299          | 127.0          | 0.052           | 64.2           | 0.699           | -33.7          |
| 0.5                | 0.479           | -74.0          | 10.887          | 119.1          | 0.060           | 61.5           | 0.628           | -37.0          |
| 0.6                | 0.409           | -83.2          | 9.542           | 112.6          | 0.066           | 60.0           | 0.557           | -39.6          |
| 0.7                | 0.361           | -92.1          | 8.545           | 107.7          | 0.073           | 60.1           | 0.511           | -41.1          |
| 0.8                | 0.320           | -99.9          | 7.672           | 102.8          | 0.078           | 59.7           | 0.463           | -42.5          |
| 0.9                | 0.289           | -108.6         | 6.931           | 99.4           | 0.084           | 59.4           | 0.432           | -43.8          |
| 1.0                | 0.267           | -116.7         | 6.341           | 95.9           | 0.090           | 59.6           | 0.399           | -44.8          |
| 1.1                | 0.249           | -124.6         | 5.818           | 92.7           | 0.096           | 59.7           | 0.380           | -45.9          |
| 1.2                | 0.237           | -132.6         | 5.394           | 89.8           | 0.102           | 60.0           | 0.356           | -46.8          |
| 1.3                | 0.228           | -139.3         | 5.007           | 87.2           | 0.108           | 59.7           | 0.345           | -47.9          |
| 1.4                | 0.220           | -147.5         | 4.668           | 84.4           | 0.113           | 59.7           | 0.327           | -48.6          |
| 1.5                | 0.215           | -153.4         | 4.389           | 82.2           | 0.120           | 59.7           | 0.320           | -49.5          |
| 1.6                | 0.214           | -160.8         | 4.125           | 79.7           | 0.126           | 59.6           | 0.303           | -50.0          |
| 1.7                | 0.216           | -166.1         | 3.905           | 77.9           | 0.132           | 59.3           | 0.296           | -51.1          |
| 1.8                | 0.213           | -173.8         | 3.704           | 75.5           | 0.138           | 59.2           | 0.281           | -51.2          |
| 1.9                | 0.210           | -177.3         | 3.537           | 73.8           | 0.144           | 59.1           | 0.274           | -52.6          |
| 2.0                | 0.223           | 178.4          | 3.345           | 71.7           | 0.150           | 58.9           | 0.262           | -52.8          |
| 2.1                | 0.228           | 175.1          | 3.206           | 69.9           | 0.156           | 58.6           | 0.256           | -54.8          |
| 2.2                | 0.233           | 172.6          | 3.088           | 68.5           | 0.162           | 58.3           | 0.247           | -55.1          |
| 2.3                | 0.235           | 169.9          | 2.968           | 66.3           | 0.168           | 58.1           | 0.243           | -57.2          |
| 2.4                | 0.241           | 165.7          | 2.861           | 65.2           | 0.173           | 57.7           | 0.237           | -57.5          |
| 2.5                | 0.247           | 163.1          | 2.740           | 63.7           | 0.179           | 57.3           | 0.233           | -59.8          |
| 2.6                | 0.256           | 159.9          | 2.649           | 61.6           | 0.185           | 56.4           | 0.230           | -60.4          |
| 2.7                | 0.256           | 157.6          | 2.579           | 60.3           | 0.191           | 56.1           | 0.225           | -62.0          |
| 2.8                | 0.263           | 155.3          | 2.484           | 58.6           | 0.197           | 55.2           | 0.222           | -62.1          |
| 2.9                | 0.264           | 153.6          | 2.410           | 57.3           | 0.204           | 55.2           | 0.217           | -63.7          |
| 3.0                | 0.265           | 150.5          | 2.333           | 55.9           | 0.209           | 54.7           | 0.211           | -63.8          |
| 4.0                | 0.321           | 132.6          | 1.799           | 41.5           | 0.267           | 50.3           | 0.173           | -84.4          |
| 5.0                | 0.412           | 120.7          | 1.518           | 28.7           | 0.325           | 43.0           | 0.102           | -110.3         |

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

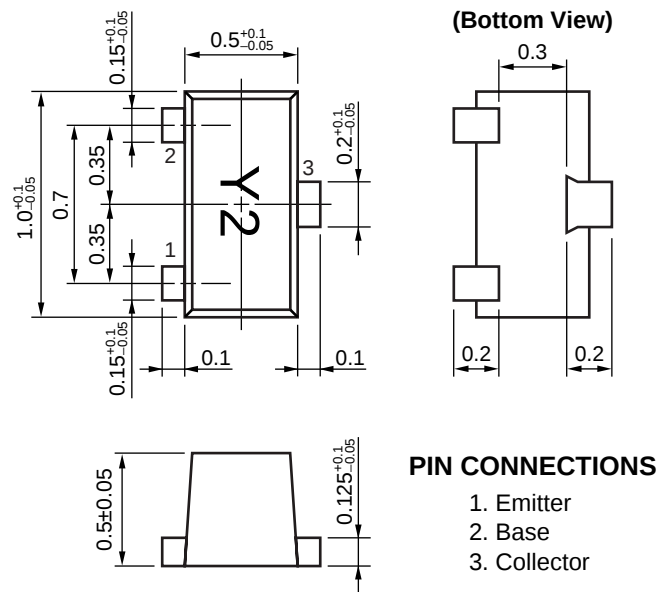
| Frequency<br>(GHz) | S <sub>11</sub> |                | S <sub>21</sub> |                | S <sub>12</sub> |                | S <sub>22</sub> |                |
|--------------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|
|                    | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) | MAG.            | ANG.<br>(deg.) |
| 0.1                | 0.698           | -22.1          | 21.714          | 159.4          | 0.015           | 78.9           | 0.936           | -13.9          |
| 0.2                | 0.628           | -41.9          | 18.942          | 143.2          | 0.029           | 70.5           | 0.828           | -24.8          |
| 0.3                | 0.517           | -58.8          | 16.006          | 131.2          | 0.039           | 66.4           | 0.722           | -31.8          |
| 0.4                | 0.447           | -71.8          | 13.661          | 121.0          | 0.047           | 64.2           | 0.623           | -36.5          |
| 0.5                | 0.384           | -83.9          | 11.809          | 113.6          | 0.054           | 62.8           | 0.554           | -38.9          |
| 0.6                | 0.325           | -93.5          | 10.206          | 107.6          | 0.060           | 62.3           | 0.488           | -40.7          |
| 0.7                | 0.288           | -103.4         | 9.052           | 103.2          | 0.067           | 62.9           | 0.446           | -41.4          |
| 0.8                | 0.255           | -112.4         | 8.059           | 98.8           | 0.073           | 62.9           | 0.404           | -42.3          |
| 0.9                | 0.235           | -121.7         | 7.252           | 95.7           | 0.079           | 63.0           | 0.377           | -43.0          |
| 1.0                | 0.221           | -130.0         | 6.589           | 92.7           | 0.085           | 63.1           | 0.349           | -43.7          |
| 1.1                | 0.209           | -138.4         | 6.034           | 89.7           | 0.092           | 63.5           | 0.334           | -44.6          |
| 1.2                | 0.205           | -146.4         | 5.576           | 86.9           | 0.098           | 63.6           | 0.314           | -45.5          |
| 1.3                | 0.199           | -153.2         | 5.163           | 84.8           | 0.104           | 63.5           | 0.306           | -46.4          |
| 1.4                | 0.200           | -160.3         | 4.808           | 82.0           | 0.111           | 63.4           | 0.289           | -47.0          |
| 1.5                | 0.200           | -166.9         | 4.516           | 80.1           | 0.118           | 63.2           | 0.285           | -47.9          |
| 1.6                | 0.201           | -173.3         | 4.229           | 77.8           | 0.124           | 63.1           | 0.270           | -48.3          |
| 1.7                | 0.207           | -177.8         | 4.008           | 76.2           | 0.130           | 62.7           | 0.265           | -49.4          |
| 1.8                | 0.210           | 175.4          | 3.800           | 73.9           | 0.136           | 62.3           | 0.251           | -49.6          |
| 1.9                | 0.205           | 172.4          | 3.625           | 72.3           | 0.143           | 62.2           | 0.246           | -51.0          |
| 2.0                | 0.219           | 169.3          | 3.432           | 70.3           | 0.149           | 61.9           | 0.234           | -51.1          |
| 2.1                | 0.229           | 166.7          | 3.285           | 68.7           | 0.155           | 61.4           | 0.229           | -53.4          |
| 2.2                | 0.231           | 163.7          | 3.164           | 67.3           | 0.162           | 61.2           | 0.221           | -53.6          |
| 2.3                | 0.232           | 161.7          | 3.039           | 65.2           | 0.168           | 60.7           | 0.218           | -56.0          |
| 2.4                | 0.241           | 158.2          | 2.931           | 64.3           | 0.174           | 60.1           | 0.213           | -56.4          |
| 2.5                | 0.247           | 156.5          | 2.807           | 62.8           | 0.180           | 59.7           | 0.209           | -58.9          |
| 2.6                | 0.257           | 153.9          | 2.705           | 60.9           | 0.186           | 58.7           | 0.206           | -59.4          |
| 2.7                | 0.256           | 152.4          | 2.632           | 59.5           | 0.193           | 58.2           | 0.202           | -61.2          |
| 2.8                | 0.262           | 149.6          | 2.539           | 57.9           | 0.199           | 57.5           | 0.200           | -61.3          |
| 2.9                | 0.265           | 148.3          | 2.463           | 56.7           | 0.206           | 57.2           | 0.194           | -63.1          |
| 3.0                | 0.268           | 145.7          | 2.385           | 55.3           | 0.212           | 56.6           | 0.189           | -63.1          |
| 4.0                | 0.323           | 129.9          | 1.836           | 41.4           | 0.272           | 51.4           | 0.154           | -85.9          |
| 5.0                | 0.413           | 119.5          | 1.549           | 28.7           | 0.330           | 43.6           | 0.085           | -116.8         |

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

| 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                | 0.523           | -33.8          | 28.767          | 152.2          | 0.014           | 75.2           | 0.871           | -18.6          |
| 0.2                | 0.443           | -59.0          | 22.932          | 132.7          | 0.025           | 70.5           | 0.713           | -30.2          |
| 0.3                | 0.342           | -79.9          | 18.030          | 120.8          | 0.032           | 66.8           | 0.592           | -35.2          |
| 0.4                | 0.292           | -96.0          | 14.632          | 111.5          | 0.039           | 67.4           | 0.500           | -37.4          |
| 0.5                | 0.261           | -109.0         | 12.228          | 105.2          | 0.046           | 67.3           | 0.444           | -37.6          |
| 0.6                | 0.225           | -121.7         | 10.407          | 100.2          | 0.053           | 67.6           | 0.393           | -37.7          |
| 0.7                | 0.208           | -132.4         | 9.113           | 96.7           | 0.060           | 68.7           | 0.365           | -37.3          |
| 0.8                | 0.195           | -142.9         | 8.038           | 92.9           | 0.066           | 68.7           | 0.334           | -37.2          |
| 0.9                | 0.193           | -152.5         | 7.192           | 90.3           | 0.073           | 68.9           | 0.316           | -37.5          |
| 1.0                | 0.192           | -159.8         | 6.505           | 87.7           | 0.080           | 68.9           | 0.295           | -37.8          |
| 1.1                | 0.195           | -167.2         | 5.924           | 85.3           | 0.087           | 69.1           | 0.286           | -38.7          |
| 1.2                | 0.199           | -172.6         | 5.475           | 82.9           | 0.094           | 69.1           | 0.271           | -39.3          |
| 1.3                | 0.202           | -177.5         | 5.051           | 80.9           | 0.101           | 68.6           | 0.267           | -40.4          |
| 1.4                | 0.208           | 176.9          | 4.707           | 78.5           | 0.107           | 68.4           | 0.255           | -40.9          |
| 1.5                | 0.210           | 172.6          | 4.410           | 76.8           | 0.115           | 68.1           | 0.253           | -42.0          |
| 1.6                | 0.219           | 167.4          | 4.136           | 74.7           | 0.121           | 67.6           | 0.241           | -42.4          |
| 1.7                | 0.228           | 165.8          | 3.912           | 73.2           | 0.128           | 67.1           | 0.238           | -43.8          |
| 1.8                | 0.232           | 159.9          | 3.705           | 71.1           | 0.135           | 66.7           | 0.227           | -43.8          |
| 1.9                | 0.230           | 158.3          | 3.532           | 69.6           | 0.141           | 66.3           | 0.223           | -45.6          |
| 2.0                | 0.243           | 156.2          | 3.337           | 67.7           | 0.148           | 65.8           | 0.213           | -45.6          |
| 2.1                | 0.252           | 154.5          | 3.198           | 66.2           | 0.155           | 65.2           | 0.210           | -48.3          |
| 2.2                | 0.256           | 153.0          | 3.079           | 64.9           | 0.161           | 64.7           | 0.203           | -48.6          |
| 2.3                | 0.257           | 151.0          | 2.961           | 63.0           | 0.168           | 64.2           | 0.200           | -51.1          |
| 2.4                | 0.265           | 148.4          | 2.851           | 62.0           | 0.174           | 63.5           | 0.196           | -51.7          |
| 2.5                | 0.272           | 147.5          | 2.731           | 60.7           | 0.181           | 62.9           | 0.192           | -54.5          |
| 2.6                | 0.280           | 145.1          | 2.632           | 58.7           | 0.187           | 61.9           | 0.190           | -55.1          |
| 2.7                | 0.281           | 144.3          | 2.563           | 57.5           | 0.193           | 61.2           | 0.187           | -57.3          |
| 2.8                | 0.290           | 142.2          | 2.468           | 56.0           | 0.200           | 60.3           | 0.185           | -57.4          |
| 2.9                | 0.290           | 141.5          | 2.399           | 54.8           | 0.207           | 60.0           | 0.180           | -59.4          |
| 3.0                | 0.294           | 139.2          | 2.318           | 53.5           | 0.213           | 59.3           | 0.176           | -59.6          |
| 4.0                | 0.349           | 125.6          | 1.781           | 39.9           | 0.275           | 53.2           | 0.144           | -84.7          |
| 5.0                | 0.432           | 116.5          | 1.499           | 27.5           | 0.334           | 44.9           | 0.078           | -119.3         |

PACKAGE DIMENSIONS

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



PIN CONNECTIONS

1. Emitter
2. Base
3. Collector

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