

HIGH-FREQUENCY LOW-NOISE AMPLIFIER

NPN SILICON EPITAXIAL TWIN TRANSISTOR

(WITH BUILT-IN 6-PIN 2 × 2SC5184) THIN-TYPE SMALL MINI MOLD

FEATURES

- Low noise
 $NF = 1.3 \text{ dB TYP. @ } V_{CE} = 2 \text{ V, } I_c = 3 \text{ mA, } f = 2 \text{ GHz}$
 $NF = 1.3 \text{ dB TYP. @ } V_{CE} = 1 \text{ V, } I_c = 3 \text{ mA, } f = 2 \text{ GHz}$
- 6-pin thin-type small mini mold package adopted
- Built-in 2 transistors (2 × 2SC5184)

ORDERING INFORMATION

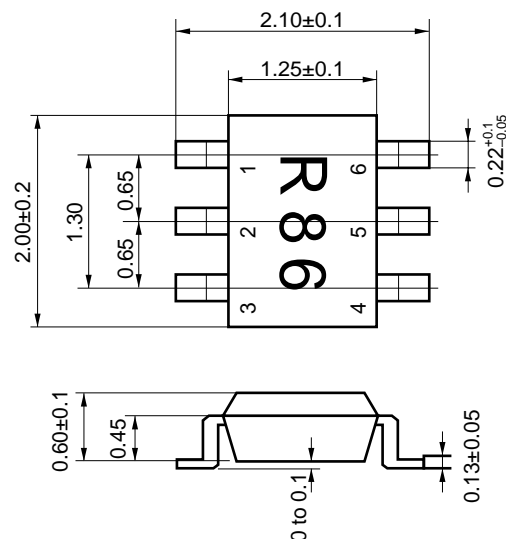
| Part Number | Quantity | Packing Style |
|------------------|----------------------------------|--|
| μ PA828TF | Loose products (50 pcs) | Embossed tape 8 mm wide. Pin 6 (Q1 Base), Pin 5 (Q2 Emitter), Pin 4 (Q2 Base) face to perforation side of the tape. |
| μ PA828TF-T1 | Taping products (3 kpcs/reel) | |

Remark If you require an evaluation sample, please contact an NEC Sales Representative (Unit sample quantity is 50 pcs).

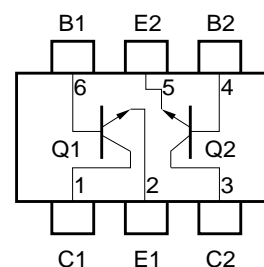
ABSOLUTE MAXIMUM RATINGS ($T_A = 25^\circ\text{C}$)

| Parameter | Symbol | Rating | Unit |
|------------------------------|-----------|--------------------------------------|------------------|
| Collector to Base Voltage | V_{CBO} | 5 | V |
| Collector to Emitter Voltage | V_{CEO} | 3 | V |
| Emitter to Base Voltage | V_{EBO} | 2 | V |
| Collector Current | I_c | 30 | mA |
| Total Power Dissipation | P_T | 90 in 1 element 180 in 2 elements | mW |
| Junction Temperature | T_j | 150 | $^\circ\text{C}$ |
| Storage Temperature | T_{stg} | -65 to +150 | $^\circ\text{C}$ |

PACKAGE DRAWINGS (Unit: mm)



PIN CONFIGURATION (Top View)



PIN CONNECTIONS

- | | |
|-------------------|-----------------|
| 1. Collector (Q1) | 4. Base (Q2) |
| 2. Emitter (Q1) | 5. Emitter (Q2) |
| 3. Collector (Q2) | 6. Base (Q1) |

Caution is required concerning excess input, such as from static electricity, due to the high-precision fabrication processes used for this device.

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

| Parameter | Symbol | Condition | MIN. | TYP. | MAX. | Unit |
|----------------------------|------------------------------------|--|------|------|------|------|
| Collector Cutoff Current | I _{CBO} | V _{CB} = 5 V, I _E = 0 | | | 0.1 | μA |
| Emitter Cutoff Current | I _{EB0} | V _{EB} = 1 V, I _C = 0 | | | 0.1 | μA |
| DC Current Gain | h _{FE} | V _{CE} = 2 V, I _C = 20 mA ^{Note 1} | 70 | | 140 | |
| Gain Bandwidth Product (1) | f _T | V _{CE} = 2 V, I _C = 20 mA, f = 2 GHz | 9 | 11 | | GHz |
| Gain Bandwidth Product (2) | f _T | V _{CE} = 1 V, I _C = 10 mA, f = 2 GHz | 7 | 9 | | GHz |
| Feedback Capacitance | C _{re} | V _{CB} = 2 V, I _E = 0, f = 1 MHz ^{Note 2} | | 0.4 | 0.8 | pF |
| Insertion Power Gain (1) | S _{21e} ² | V _{CE} = 2 V, I _C = 20 mA, f = 2 GHz | 7 | 8.5 | | dB |
| Insertion Power Gain (2) | S _{21e} ² | V _{CE} = 1 V, I _C = 10 mA, f = 2 GHz | 6 | 7.5 | | dB |
| Noise Figure (1) | NF | V _{CE} = 2 V, I _C = 3 mA, f = 2 GHz | | 1.3 | 2 | dB |
| Noise Figure (2) | NF | V _{CE} = 1 V, I _C = 3 mA, f = 2 GHz | | 1.3 | 2 | dB |
| h _{FE} Ratio | h _{FE1} /h _{FE2} | V _{CE} = 2 V, I _C = 20 mA h _{FE1} = smaller h _{FE} value among Q1 and Q2 h _{FE2} = larger h _{FE} value among Q1 and Q2 | 0.85 | | | |

Notes 1. Pulse measurement P_W ≤ 350 μs, Duty cycle ≤ 2%

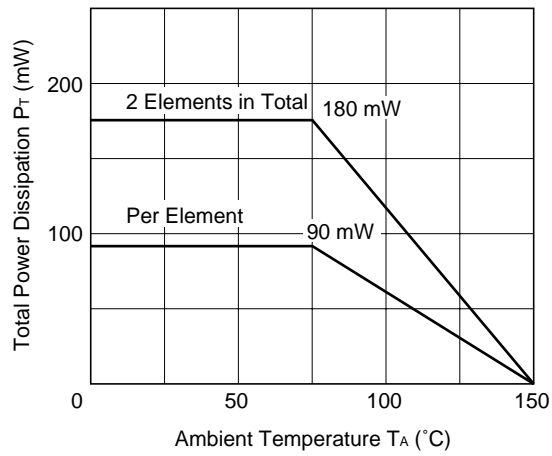
2. Capacitance between collector and base measured with a capacitance meter (auto-balancing bridge method). Emitter should be connected to the guard pin of capacitance meter.

h_{FE} CLASSIFICATION

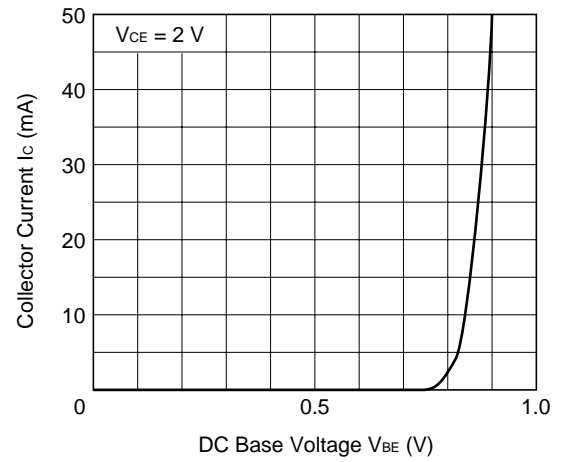
| | |
|-----------------------|-----------|
| Rank | KB |
| Marking | R86 |
| h _{FE} value | 70 to 140 |

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

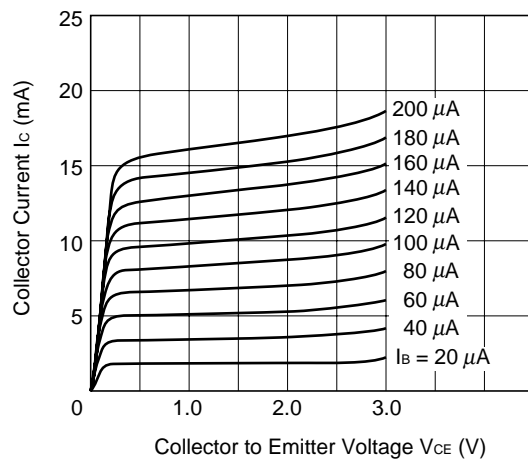
Total Power Dissipation vs. Ambient Temperature



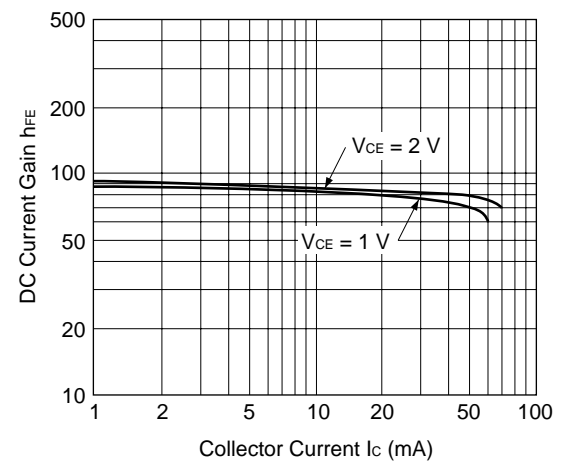
Collector Current vs. DC Base Voltage



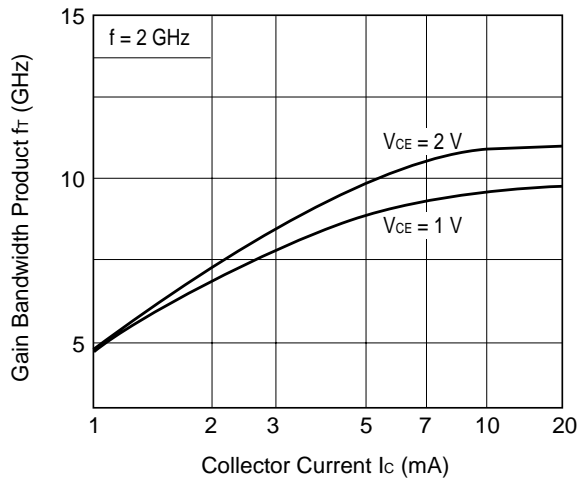
Collector Current vs. Collector to Emitter Voltage



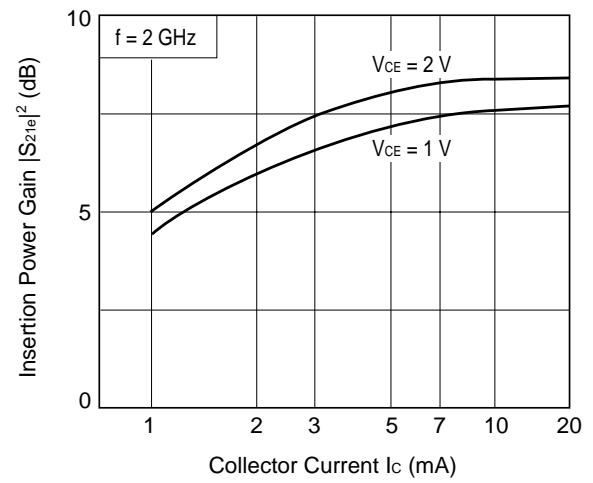
DC Current Gain vs. Collector Current



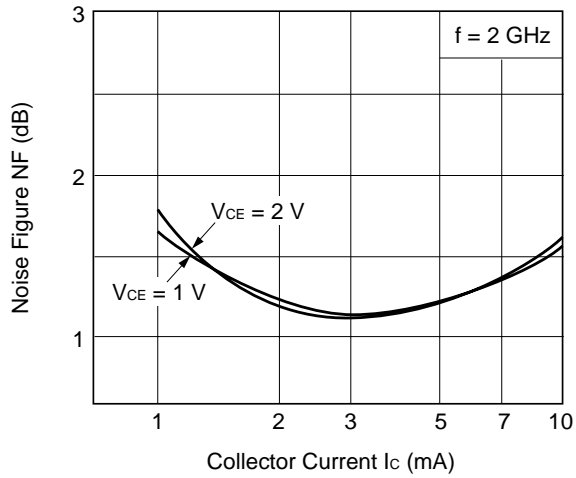
Gain Bandwidth Product vs. Collector Current



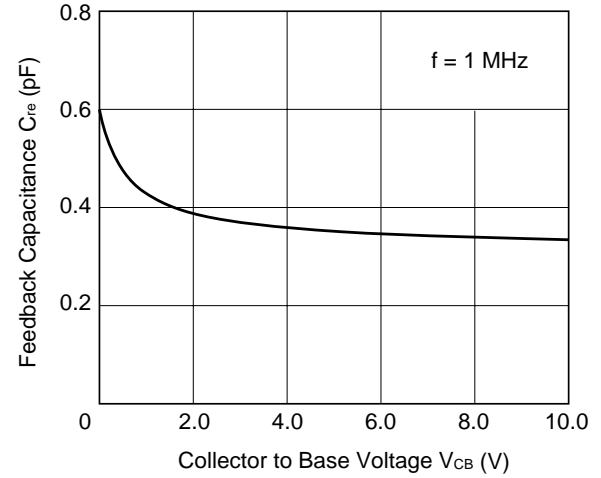
Insertion Power Gain vs. Collector Current



Noise Figure vs. Collector Current



Feedback Capacitance vs. Collector to Base Voltage



S PARAMETER Q1 $V_{CE} = 2\text{ V}$, $I_c = 1\text{ mA}$, $Z_0 = 50\ \Omega$

| FREQUENCY GHz | S ₁₁ | | S ₂₁ | | S ₁₂ | | S ₂₂ | |
|------------------|-----------------|---------|-----------------|--------|-----------------|-------|-----------------|--------|
| | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. |
| .10 | .98 | -6.87 | 2.42 | 171.77 | .02 | 84.43 | .99 | -4.42 |
| .20 | .96 | -13.71 | 2.40 | 164.17 | .04 | 79.61 | .99 | -8.84 |
| .30 | .95 | -20.79 | 2.42 | 157.17 | .07 | 74.54 | .97 | -12.97 |
| .40 | .92 | -27.69 | 2.39 | 150.27 | .09 | 69.50 | .95 | -17.23 |
| .50 | .90 | -34.82 | 2.39 | 143.98 | .10 | 65.17 | .92 | -21.05 |
| .60 | .87 | -42.10 | 2.36 | 138.23 | .12 | 60.29 | .90 | -25.13 |
| .70 | .83 | -49.35 | 2.34 | 132.19 | .14 | 56.25 | .87 | -28.47 |
| .80 | .80 | -56.87 | 2.32 | 126.78 | .15 | 52.12 | .84 | -32.22 |
| .90 | .76 | -64.78 | 2.32 | 120.75 | .16 | 48.48 | .81 | -34.98 |
| 1.00 | .72 | -72.15 | 2.26 | 115.35 | .17 | 45.16 | .77 | -38.02 |
| 1.10 | .68 | -80.50 | 2.25 | 110.20 | .18 | 41.64 | .75 | -40.84 |
| 1.20 | .64 | -88.71 | 2.22 | 104.80 | .18 | 38.79 | .72 | -43.16 |
| 1.30 | .60 | -97.33 | 2.16 | 99.84 | .19 | 35.82 | .69 | -45.68 |
| 1.40 | .56 | -106.17 | 2.13 | 94.75 | .19 | 33.51 | .66 | -47.79 |
| 1.50 | .53 | -115.63 | 2.10 | 89.64 | .20 | 31.12 | .63 | -49.93 |
| 1.60 | .50 | -124.41 | 2.04 | 84.89 | .20 | 29.04 | .61 | -51.89 |
| 1.70 | .47 | -133.52 | 1.99 | 80.39 | .20 | 27.37 | .59 | -53.75 |
| 1.80 | .45 | -142.93 | 1.93 | 75.97 | .20 | 25.64 | .57 | -55.61 |
| 1.90 | .44 | -152.17 | 1.87 | 71.81 | .20 | 24.28 | .55 | -57.34 |
| 2.00 | .43 | -161.16 | 1.81 | 68.21 | .20 | 23.31 | .53 | -59.13 |
| 2.10 | .42 | -170.55 | 1.77 | 63.89 | .20 | 22.18 | .51 | -60.65 |
| 2.20 | .41 | -179.15 | 1.72 | 60.35 | .20 | 21.50 | .50 | -62.47 |
| 2.30 | .42 | 173.21 | 1.66 | 56.62 | .20 | 20.78 | .48 | -64.18 |
| 2.40 | .42 | 165.82 | 1.61 | 53.39 | .20 | 20.36 | .47 | -66.09 |
| 2.50 | .43 | 158.63 | 1.57 | 50.02 | .20 | 20.11 | .46 | -67.98 |
| 2.60 | .44 | 152.11 | 1.52 | 47.07 | .20 | 20.00 | .45 | -69.96 |
| 2.70 | .45 | 146.49 | 1.47 | 43.96 | .20 | 19.86 | .43 | -72.10 |
| 2.80 | .46 | 140.70 | 1.43 | 41.06 | .20 | 20.11 | .43 | -74.42 |
| 2.90 | .47 | 135.62 | 1.39 | 38.16 | .20 | 20.18 | .42 | -76.70 |
| 3.00 | .48 | 131.49 | 1.35 | 35.61 | .20 | 20.44 | .41 | -79.07 |

S PARAMETER Q1 $V_{CE} = 2 \text{ V}$, $I_C = 3 \text{ mA}$, $Z_0 = 50 \Omega$

| FREQUENCY GHz | S ₁₁ | | S ₂₁ | | S ₁₂ | | S ₂₂ | |
|------------------|-----------------|---------|-----------------|--------|-----------------|-------|-----------------|--------|
| | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. |
| .10 | .92 | -10.76 | 6.79 | 166.90 | .02 | 81.64 | .97 | -8.65 |
| .20 | .88 | -21.14 | 6.51 | 156.23 | .04 | 74.96 | .94 | -16.65 |
| .30 | .83 | -31.82 | 6.40 | 146.87 | .06 | 68.78 | .88 | -23.55 |
| .40 | .78 | -42.04 | 6.16 | 138.45 | .07 | 63.27 | .82 | -29.88 |
| .50 | .71 | -52.43 | 5.95 | 130.70 | .09 | 59.72 | .76 | -34.56 |
| .60 | .65 | -62.50 | 5.66 | 123.90 | .10 | 55.61 | .70 | -39.19 |
| .70 | .58 | -72.69 | 5.43 | 116.65 | .10 | 53.36 | .65 | -42.35 |
| .80 | .51 | -82.82 | 5.17 | 110.41 | .11 | 51.17 | .61 | -45.67 |
| .90 | .45 | -92.60 | 4.88 | 104.31 | .12 | 49.32 | .57 | -48.15 |
| 1.00 | .40 | -102.47 | 4.60 | 98.90 | .12 | 48.24 | .53 | -50.32 |
| 1.10 | .36 | -112.48 | 4.34 | 94.04 | .13 | 47.06 | .50 | -52.49 |
| 1.20 | .32 | -122.73 | 4.09 | 89.32 | .14 | 46.16 | .47 | -54.24 |
| 1.30 | .30 | -133.29 | 3.85 | 85.28 | .14 | 45.46 | .45 | -56.10 |
| 1.40 | .27 | -144.06 | 3.64 | 81.23 | .15 | 44.88 | .43 | -57.94 |
| 1.50 | .26 | -155.19 | 3.45 | 77.48 | .15 | 44.14 | .41 | -59.86 |
| 1.60 | .25 | -165.56 | 3.26 | 74.10 | .16 | 43.48 | .39 | -61.58 |
| 1.70 | .25 | -175.58 | 3.10 | 70.82 | .16 | 42.97 | .37 | -63.35 |
| 1.80 | .26 | 174.75 | 2.95 | 67.58 | .17 | 42.46 | .35 | -65.35 |
| 1.90 | .26 | 166.25 | 2.82 | 64.50 | .17 | 41.71 | .34 | -67.39 |
| 2.00 | .27 | 158.59 | 2.69 | 61.59 | .18 | 41.41 | .32 | -69.29 |
| 2.10 | .28 | 151.33 | 2.58 | 58.69 | .19 | 40.78 | .31 | -71.31 |
| 2.20 | .29 | 145.02 | 2.47 | 56.03 | .19 | 40.10 | .30 | -73.78 |
| 2.30 | .31 | 139.72 | 2.36 | 53.27 | .20 | 39.55 | .29 | -76.10 |
| 2.40 | .32 | 134.63 | 2.28 | 50.82 | .20 | 39.01 | .28 | -78.86 |
| 2.50 | .34 | 130.11 | 2.20 | 48.23 | .21 | 38.47 | .27 | -81.85 |
| 2.60 | .35 | 126.08 | 2.12 | 45.78 | .21 | 37.90 | .26 | -84.98 |
| 2.70 | .37 | 122.46 | 2.04 | 43.24 | .22 | 37.28 | .25 | -88.17 |
| 2.80 | .38 | 119.06 | 1.97 | 41.09 | .22 | 36.67 | .24 | -91.66 |
| 2.90 | .40 | 115.90 | 1.91 | 38.67 | .23 | 35.90 | .23 | -95.45 |
| 3.00 | .41 | 113.18 | 1.85 | 36.49 | .23 | 35.19 | .22 | -99.22 |

S PARAMETER Q1 $V_{CE} = 2\text{ V}$, $I_c = 5\text{ mA}$, $Z_0 = 50\ \Omega$

| FREQUENCY GHz | S ₁₁ | | S ₂₁ | | S ₁₂ | | S ₂₂ | |
|------------------|-----------------|---------|-----------------|--------|-----------------|-------|-----------------|---------|
| | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. |
| .10 | .87 | -14.09 | 10.64 | 163.29 | .02 | 79.93 | .95 | -11.97 |
| .20 | .81 | -27.42 | 9.95 | 150.51 | .04 | 72.08 | .88 | -22.31 |
| .30 | .73 | -40.88 | 9.52 | 139.49 | .05 | 66.23 | .79 | -30.28 |
| .40 | .64 | -53.67 | 8.93 | 129.93 | .06 | 61.90 | .71 | -36.76 |
| .50 | .55 | -65.97 | 8.31 | 121.13 | .07 | 59.41 | .64 | -41.09 |
| .60 | .48 | -77.45 | 7.63 | 113.73 | .08 | 57.14 | .58 | -45.05 |
| .70 | .40 | -88.32 | 7.00 | 106.72 | .09 | 55.84 | .53 | -47.68 |
| .80 | .34 | -99.03 | 6.43 | 100.97 | .10 | 55.02 | .49 | -50.09 |
| .90 | .30 | -109.36 | 5.89 | 95.86 | .11 | 54.11 | .45 | -52.09 |
| 1.00 | .26 | -120.28 | 5.43 | 91.26 | .11 | 53.70 | .43 | -53.78 |
| 1.10 | .23 | -131.28 | 5.02 | 87.25 | .12 | 53.10 | .40 | -55.60 |
| 1.20 | .21 | -143.41 | 4.67 | 83.34 | .13 | 52.72 | .38 | -57.08 |
| 1.30 | .20 | -155.46 | 4.36 | 79.89 | .13 | 52.14 | .36 | -58.90 |
| 1.40 | .20 | -167.22 | 4.08 | 76.55 | .14 | 51.70 | .34 | -60.77 |
| 1.50 | .20 | -178.69 | 3.84 | 73.31 | .15 | 50.94 | .32 | -62.84 |
| 1.60 | .20 | 171.39 | 3.62 | 70.48 | .15 | 50.53 | .31 | -64.74 |
| 1.70 | .21 | 162.38 | 3.42 | 67.63 | .16 | 49.64 | .30 | -66.88 |
| 1.80 | .22 | 154.33 | 3.24 | 64.82 | .17 | 48.93 | .28 | -69.18 |
| 1.90 | .23 | 147.57 | 3.08 | 62.01 | .18 | 48.25 | .27 | -71.53 |
| 2.00 | .25 | 141.55 | 2.93 | 59.55 | .18 | 47.47 | .26 | -74.05 |
| 2.10 | .26 | 136.15 | 2.81 | 57.06 | .19 | 46.67 | .25 | -76.68 |
| 2.20 | .28 | 131.40 | 2.69 | 54.66 | .20 | 45.88 | .24 | -80.23 |
| 2.30 | .29 | 127.31 | 2.58 | 52.10 | .20 | 44.80 | .23 | -83.11 |
| 2.40 | .31 | 123.63 | 2.48 | 49.88 | .21 | 44.22 | .22 | -86.87 |
| 2.50 | .32 | 120.25 | 2.38 | 47.59 | .22 | 43.28 | .21 | -90.62 |
| 2.60 | .34 | 117.23 | 2.29 | 45.27 | .22 | 42.22 | .20 | -94.98 |
| 2.70 | .36 | 114.23 | 2.21 | 42.96 | .23 | 41.37 | .19 | -99.37 |
| 2.80 | .37 | 111.67 | 2.13 | 40.88 | .23 | 40.49 | .19 | -104.32 |
| 2.90 | .39 | 109.21 | 2.07 | 38.78 | .24 | 39.37 | .18 | -109.07 |
| 3.00 | .40 | 107.18 | 1.99 | 36.87 | .25 | 38.39 | .18 | -114.10 |

S PARAMETER Q1 $V_{CE} = 2 \text{ V}$, $I_C = 7 \text{ mA}$, $Z_0 = 50 \Omega$

| FREQUENCY GHz | S ₁₁ | | S ₂₁ | | S ₁₂ | | S ₂₂ | |
|------------------|-----------------|---------|-----------------|--------|-----------------|-------|-----------------|---------|
| | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. |
| .10 | .82 | -17.05 | 14.01 | 160.40 | .02 | 78.68 | .92 | -14.71 |
| .20 | .74 | -33.00 | 12.83 | 146.00 | .04 | 70.70 | .83 | -26.46 |
| .30 | .63 | -48.73 | 11.93 | 133.68 | .05 | 65.62 | .72 | -34.67 |
| .40 | .53 | -63.25 | 10.85 | 123.20 | .06 | 62.00 | .63 | -40.72 |
| .50 | .44 | -76.15 | 9.73 | 114.26 | .07 | 60.73 | .56 | -44.46 |
| .60 | .36 | -87.70 | 8.66 | 107.33 | .08 | 59.44 | .50 | -47.65 |
| .70 | .30 | -98.68 | 7.74 | 101.13 | .08 | 58.70 | .46 | -49.83 |
| .80 | .26 | -109.94 | 6.98 | 96.02 | .09 | 58.45 | .42 | -51.77 |
| .90 | .22 | -121.35 | 6.33 | 91.57 | .10 | 58.02 | .39 | -53.47 |
| 1.00 | .20 | -133.61 | 5.79 | 87.48 | .11 | 57.58 | .37 | -54.96 |
| 1.10 | .18 | -146.14 | 5.31 | 83.89 | .12 | 57.18 | .35 | -56.63 |
| 1.20 | .17 | -159.26 | 4.92 | 80.50 | .12 | 56.65 | .33 | -58.16 |
| 1.30 | .17 | -171.86 | 4.58 | 77.32 | .13 | 55.98 | .31 | -59.87 |
| 1.40 | .17 | 176.63 | 4.27 | 74.26 | .14 | 55.31 | .30 | -61.97 |
| 1.50 | .18 | 166.28 | 4.01 | 71.38 | .15 | 54.65 | .28 | -64.19 |
| 1.60 | .19 | 157.38 | 3.77 | 68.66 | .15 | 53.86 | .27 | -66.38 |
| 1.70 | .20 | 149.88 | 3.56 | 66.07 | .16 | 53.13 | .26 | -68.92 |
| 1.80 | .21 | 143.24 | 3.38 | 63.48 | .17 | 52.19 | .25 | -71.37 |
| 1.90 | .23 | 137.70 | 3.21 | 60.92 | .18 | 51.24 | .24 | -74.34 |
| 2.00 | .24 | 132.73 | 3.06 | 58.46 | .18 | 50.37 | .23 | -77.26 |
| 2.10 | .26 | 128.44 | 2.92 | 56.09 | .19 | 49.52 | .22 | -80.38 |
| 2.20 | .27 | 124.40 | 2.79 | 53.79 | .20 | 48.39 | .21 | -84.26 |
| 2.30 | .29 | 121.31 | 2.67 | 51.50 | .21 | 47.37 | .20 | -88.09 |
| 2.40 | .30 | 118.20 | 2.57 | 49.41 | .21 | 46.22 | .19 | -92.30 |
| 2.50 | .32 | 115.34 | 2.47 | 47.18 | .22 | 45.21 | .18 | -97.03 |
| 2.60 | .34 | 112.78 | 2.38 | 45.18 | .23 | 44.15 | .18 | -101.80 |
| 2.70 | .35 | 110.25 | 2.29 | 42.82 | .23 | 43.16 | .17 | -107.33 |
| 2.80 | .37 | 108.03 | 2.21 | 40.87 | .24 | 42.05 | .17 | -112.84 |
| 2.90 | .38 | 105.94 | 2.14 | 38.86 | .25 | 40.88 | .17 | -118.72 |
| 3.00 | .39 | 104.18 | 2.06 | 36.86 | .25 | 39.80 | .16 | -124.46 |

S PARAMETER Q1 $V_{CE} = 2 \text{ V}$, $I_c = 10 \text{ mA}$, $Z_0 = 50 \Omega$

| FREQUENCY GHz | S ₁₁ | | S ₂₁ | | S ₁₂ | | S ₂₂ | |
|------------------|-----------------|---------|-----------------|--------|-----------------|-------|-----------------|---------|
| | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. |
| .10 | .75 | -21.25 | 18.39 | 156.90 | .02 | 77.20 | .89 | -17.80 |
| .20 | .64 | -40.55 | 16.34 | 140.45 | .03 | 69.69 | .77 | -30.80 |
| .30 | .51 | -58.49 | 14.49 | 126.78 | .04 | 65.76 | .65 | -38.64 |
| .40 | .41 | -73.72 | 12.55 | 116.10 | .05 | 64.03 | .56 | -43.82 |
| .50 | .32 | -86.53 | 10.81 | 107.94 | .06 | 63.08 | .49 | -46.87 |
| .60 | .26 | -98.65 | 9.39 | 101.73 | .07 | 62.52 | .44 | -49.28 |
| .70 | .22 | -110.38 | 8.27 | 96.47 | .08 | 62.35 | .40 | -50.98 |
| .80 | .19 | -122.98 | 7.38 | 92.04 | .09 | 62.04 | .37 | -52.53 |
| .90 | .16 | -136.32 | 6.63 | 88.10 | .10 | 61.54 | .34 | -53.99 |
| 1.00 | .15 | -150.20 | 6.04 | 84.48 | .10 | 61.35 | .32 | -55.48 |
| 1.10 | .14 | -164.12 | 5.53 | 81.17 | .11 | 60.66 | .30 | -57.10 |
| 1.20 | .14 | -177.47 | 5.10 | 78.09 | .12 | 59.95 | .29 | -58.71 |
| 1.30 | .15 | 170.71 | 4.73 | 75.15 | .13 | 59.15 | .27 | -60.60 |
| 1.40 | .16 | 160.52 | 4.41 | 72.39 | .14 | 58.38 | .26 | -62.90 |
| 1.50 | .17 | 152.02 | 4.13 | 69.70 | .15 | 57.49 | .25 | -65.42 |
| 1.60 | .18 | 144.85 | 3.88 | 67.17 | .16 | 56.48 | .24 | -68.02 |
| 1.70 | .20 | 138.84 | 3.67 | 64.75 | .16 | 55.54 | .23 | -70.84 |
| 1.80 | .21 | 133.45 | 3.47 | 62.20 | .17 | 54.52 | .22 | -74.09 |
| 1.90 | .23 | 129.28 | 3.29 | 59.90 | .18 | 53.48 | .21 | -77.36 |
| 2.00 | .24 | 125.28 | 3.13 | 57.58 | .19 | 52.37 | .20 | -80.75 |
| 2.10 | .26 | 121.80 | 2.99 | 55.23 | .20 | 51.30 | .19 | -84.72 |
| 2.20 | .27 | 118.50 | 2.85 | 53.15 | .20 | 50.15 | .18 | -89.55 |
| 2.30 | .28 | 116.06 | 2.73 | 50.91 | .21 | 48.75 | .18 | -94.27 |
| 2.40 | .30 | 113.97 | 2.63 | 49.04 | .22 | 47.87 | .17 | -99.35 |
| 2.50 | .32 | 111.91 | 2.53 | 46.95 | .22 | 46.88 | .16 | -104.52 |
| 2.60 | .33 | 109.85 | 2.43 | 45.01 | .23 | 45.56 | .16 | -110.37 |
| 2.70 | .35 | 107.73 | 2.35 | 42.94 | .24 | 44.64 | .15 | -116.16 |
| 2.80 | .36 | 105.72 | 2.26 | 40.96 | .25 | 43.33 | .15 | -122.09 |
| 2.90 | .38 | 103.86 | 2.19 | 38.82 | .25 | 42.06 | .15 | -128.50 |
| 3.00 | .39 | 102.41 | 2.12 | 36.99 | .26 | 40.73 | .15 | -134.83 |

S PARAMETER Q1 $V_{CE} = 2\text{ V}$, $I_C = 20\text{ mA}$, $Z_0 = 50\ \Omega$

| FREQUENCY GHz | S ₁₁ | | S ₂₁ | | S ₁₂ | | S ₂₂ | |
|------------------|-----------------|---------|-----------------|--------|-----------------|-------|-----------------|---------|
| | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. |
| .10 | .56 | -32.81 | 27.95 | 148.87 | .02 | 75.30 | .81 | -23.54 |
| .20 | .42 | -58.87 | 22.23 | 128.52 | .03 | 70.35 | .64 | -37.09 |
| .30 | .30 | -78.37 | 17.58 | 115.09 | .04 | 68.59 | .51 | -43.16 |
| .40 | .23 | -94.58 | 14.16 | 106.19 | .05 | 68.35 | .43 | -46.08 |
| .50 | .18 | -109.66 | 11.73 | 99.79 | .06 | 68.61 | .38 | -47.60 |
| .60 | .15 | -124.96 | 9.97 | 94.85 | .07 | 68.48 | .34 | -48.85 |
| .70 | .13 | -140.67 | 8.66 | 90.57 | .08 | 68.04 | .31 | -49.86 |
| .80 | .12 | -156.60 | 7.65 | 86.95 | .08 | 67.57 | .29 | -51.00 |
| .90 | .12 | -171.52 | 6.85 | 83.61 | .09 | 66.89 | .27 | -52.09 |
| 1.00 | .13 | 175.13 | 6.20 | 80.43 | .10 | 66.27 | .26 | -53.64 |
| 1.10 | .13 | 163.97 | 5.66 | 77.71 | .11 | 65.45 | .25 | -55.27 |
| 1.20 | .15 | 154.42 | 5.21 | 74.78 | .12 | 64.40 | .24 | -57.12 |
| 1.30 | .16 | 147.03 | 4.83 | 72.31 | .13 | 63.42 | .23 | -59.41 |
| 1.40 | .17 | 140.47 | 4.49 | 69.76 | .14 | 62.32 | .22 | -62.02 |
| 1.50 | .19 | 135.04 | 4.20 | 67.22 | .15 | 61.17 | .21 | -65.08 |
| 1.60 | .20 | 130.59 | 3.95 | 64.99 | .16 | 59.98 | .20 | -68.14 |
| 1.70 | .21 | 126.81 | 3.73 | 62.80 | .17 | 58.57 | .19 | -71.65 |
| 1.80 | .23 | 123.18 | 3.52 | 60.44 | .17 | 57.56 | .18 | -75.39 |
| 1.90 | .24 | 120.21 | 3.34 | 58.24 | .18 | 56.02 | .17 | -79.66 |
| 2.00 | .26 | 117.40 | 3.17 | 55.90 | .19 | 55.05 | .17 | -83.64 |
| 2.10 | .27 | 114.82 | 3.03 | 53.92 | .20 | 53.52 | .16 | -88.38 |
| 2.20 | .28 | 112.46 | 2.89 | 51.91 | .21 | 52.23 | .15 | -94.64 |
| 2.30 | .30 | 110.58 | 2.77 | 49.69 | .21 | 50.93 | .15 | -100.20 |
| 2.40 | .31 | 108.94 | 2.66 | 47.74 | .22 | 49.90 | .14 | -106.66 |
| 2.50 | .33 | 107.46 | 2.55 | 46.23 | .23 | 48.66 | .14 | -112.73 |
| 2.60 | .34 | 105.83 | 2.46 | 44.04 | .24 | 47.36 | .14 | -119.23 |
| 2.70 | .36 | 104.14 | 2.38 | 42.09 | .24 | 46.17 | .14 | -126.19 |
| 2.80 | .37 | 102.49 | 2.29 | 39.95 | .25 | 44.61 | .14 | -132.72 |
| 2.90 | .39 | 100.92 | 2.22 | 38.17 | .26 | 43.48 | .14 | -139.72 |
| 3.00 | .40 | 99.59 | 2.14 | 36.41 | .27 | 42.04 | .14 | -146.05 |

S PARAMETER Q2 $V_{CE} = 2\text{ V}$, $I_c = 1\text{ mA}$, $Z_0 = 50\ \Omega$

| FREQUENCY GHz | S ₁₁ | | S ₂₁ | | S ₁₂ | | S ₂₂ | |
|------------------|-----------------|---------|-----------------|--------|-----------------|-------|-----------------|--------|
| | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. |
| .10 | .98 | -6.74 | 2.44 | 171.33 | .02 | 84.61 | .99 | -4.39 |
| .20 | .96 | -13.51 | 2.41 | 163.49 | .04 | 79.80 | .98 | -8.74 |
| .30 | .94 | -20.37 | 2.43 | 156.32 | .06 | 74.82 | .96 | -12.93 |
| .40 | .92 | -27.07 | 2.39 | 149.41 | .08 | 69.91 | .94 | -17.05 |
| .50 | .89 | -33.96 | 2.39 | 143.02 | .10 | 65.85 | .91 | -20.67 |
| .60 | .86 | -40.84 | 2.37 | 137.27 | .12 | 61.45 | .88 | -24.51 |
| .70 | .83 | -47.75 | 2.34 | 131.22 | .13 | 57.88 | .85 | -27.55 |
| .80 | .80 | -54.58 | 2.32 | 125.82 | .14 | 54.28 | .81 | -30.99 |
| .90 | .76 | -61.78 | 2.31 | 119.93 | .15 | 51.24 | .78 | -33.61 |
| 1.00 | .72 | -68.15 | 2.25 | 114.65 | .16 | 48.38 | .74 | -36.17 |
| 1.10 | .68 | -75.40 | 2.24 | 109.63 | .17 | 45.66 | .71 | -38.83 |
| 1.20 | .64 | -82.34 | 2.20 | 104.41 | .18 | 43.56 | .68 | -40.86 |
| 1.30 | .61 | -89.46 | 2.15 | 99.72 | .18 | 41.47 | .65 | -43.15 |
| 1.40 | .57 | -96.54 | 2.12 | 94.60 | .19 | 39.81 | .62 | -45.20 |
| 1.50 | .54 | -103.94 | 2.09 | 90.06 | .19 | 38.22 | .60 | -47.35 |
| 1.60 | .51 | -110.51 | 2.04 | 85.69 | .20 | 36.90 | .57 | -49.18 |
| 1.70 | .48 | -117.50 | 1.98 | 81.41 | .20 | 35.84 | .54 | -51.11 |
| 1.80 | .46 | -124.73 | 1.94 | 77.28 | .20 | 34.52 | .52 | -53.17 |
| 1.90 | .44 | -131.81 | 1.89 | 73.42 | .20 | 34.12 | .50 | -54.98 |
| 2.00 | .43 | -138.81 | 1.84 | 69.85 | .21 | 33.47 | .48 | -57.05 |
| 2.10 | .41 | -145.59 | 1.81 | 65.84 | .21 | 33.15 | .46 | -58.98 |
| 2.20 | .40 | -152.38 | 1.76 | 62.18 | .21 | 32.61 | .44 | -61.35 |
| 2.30 | .40 | -158.62 | 1.71 | 58.78 | .21 | 32.49 | .42 | -63.57 |
| 2.40 | .39 | -164.92 | 1.67 | 55.63 | .22 | 32.58 | .40 | -66.15 |
| 2.50 | .39 | -171.15 | 1.64 | 52.42 | .22 | 32.53 | .38 | -68.86 |
| 2.60 | .39 | -176.91 | 1.60 | 49.27 | .22 | 32.66 | .36 | -71.68 |
| 2.70 | .40 | 177.60 | 1.56 | 46.17 | .23 | 32.73 | .35 | -74.91 |
| 2.80 | .40 | 172.40 | 1.53 | 43.05 | .23 | 32.98 | .33 | -78.55 |
| 2.90 | .40 | 167.39 | 1.49 | 40.32 | .23 | 33.06 | .31 | -82.01 |
| 3.00 | .41 | 163.33 | 1.45 | 37.62 | .24 | 33.20 | .30 | -86.04 |

S PARAMETER Q2 $V_{CE} = 2 \text{ V}$, $I_C = 3 \text{ mA}$, $Z_0 = 50 \Omega$

| FREQUENCY GHz | S ₁₁ | | S ₂₁ | | S ₁₂ | | S ₂₂ | |
|------------------|-----------------|---------|-----------------|--------|-----------------|-------|-----------------|--------|
| | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. |
| .10 | .92 | -10.47 | 6.76 | 165.93 | .02 | 82.05 | .97 | -8.45 |
| .20 | .88 | -20.49 | 6.45 | 154.91 | .04 | 75.09 | .93 | -16.14 |
| .30 | .83 | -30.63 | 6.30 | 145.29 | .06 | 70.11 | .86 | -22.48 |
| .40 | .77 | -40.22 | 6.03 | 136.75 | .07 | 65.40 | .80 | -27.91 |
| .50 | .70 | -49.54 | 5.79 | 128.87 | .08 | 62.38 | .73 | -31.76 |
| .60 | .64 | -58.45 | 5.49 | 121.94 | .09 | 59.22 | .68 | -35.44 |
| .70 | .57 | -66.75 | 5.22 | 114.90 | .10 | 57.58 | .62 | -37.62 |
| .80 | .51 | -74.87 | 4.94 | 108.77 | .11 | 56.19 | .58 | -39.97 |
| .90 | .46 | -82.13 | 4.64 | 102.99 | .12 | 54.96 | .54 | -41.46 |
| 1.00 | .41 | -89.08 | 4.36 | 97.91 | .13 | 54.27 | .50 | -42.75 |
| 1.10 | .37 | -95.99 | 4.10 | 93.32 | .13 | 53.56 | .47 | -44.04 |
| 1.20 | .34 | -102.50 | 3.87 | 88.99 | .14 | 53.02 | .44 | -44.99 |
| 1.30 | .31 | -109.65 | 3.65 | 85.09 | .15 | 52.49 | .42 | -45.98 |
| 1.40 | .29 | -116.40 | 3.45 | 81.35 | .16 | 51.99 | .39 | -47.12 |
| 1.50 | .27 | -123.57 | 3.28 | 77.89 | .16 | 51.26 | .37 | -48.16 |
| 1.60 | .25 | -130.78 | 3.12 | 74.56 | .17 | 50.83 | .35 | -49.18 |
| 1.70 | .24 | -137.88 | 2.97 | 71.50 | .18 | 50.47 | .33 | -50.34 |
| 1.80 | .24 | -145.39 | 2.84 | 68.40 | .19 | 49.91 | .31 | -51.49 |
| 1.90 | .23 | -152.42 | 2.72 | 65.48 | .20 | 49.22 | .29 | -52.79 |
| 2.00 | .23 | -159.55 | 2.61 | 62.61 | .20 | 48.79 | .28 | -54.18 |
| 2.10 | .23 | -166.12 | 2.52 | 59.74 | .21 | 47.95 | .26 | -55.52 |
| 2.20 | .23 | -172.60 | 2.42 | 57.16 | .22 | 47.35 | .24 | -57.44 |
| 2.30 | .24 | -178.44 | 2.34 | 54.38 | .23 | 46.58 | .22 | -59.36 |
| 2.40 | .25 | 175.70 | 2.26 | 51.87 | .24 | 45.96 | .21 | -61.25 |
| 2.50 | .26 | 170.52 | 2.19 | 49.35 | .24 | 45.28 | .19 | -64.05 |
| 2.60 | .27 | 165.72 | 2.12 | 46.80 | .25 | 44.33 | .17 | -66.72 |
| 2.70 | .28 | 161.24 | 2.06 | 44.31 | .26 | 43.50 | .16 | -70.25 |
| 2.80 | .29 | 157.30 | 2.00 | 41.90 | .27 | 42.65 | .14 | -74.78 |
| 2.90 | .30 | 153.21 | 1.95 | 39.57 | .28 | 41.59 | .12 | -80.10 |
| 3.00 | .31 | 150.49 | 1.89 | 37.22 | .29 | 40.55 | .11 | -86.71 |

S PARAMETER Q2 $V_{CE} = 2\text{ V}$, $I_c = 5\text{ mA}$, $Z_0 = 50\ \Omega$

| FREQUENCY GHz | S ₁₁ | | S ₂₁ | | S ₁₂ | | S ₂₂ | |
|------------------|-----------------|---------|-----------------|--------|-----------------|-------|-----------------|--------|
| | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. |
| .10 | .87 | -13.54 | 10.54 | 162.00 | .02 | 80.48 | .94 | -11.69 |
| .20 | .80 | -26.19 | 9.77 | 148.74 | .04 | 73.48 | .87 | -21.26 |
| .30 | .72 | -38.63 | 9.27 | 137.38 | .05 | 68.44 | .77 | -27.99 |
| .40 | .63 | -49.88 | 8.60 | 127.63 | .06 | 65.14 | .69 | -32.99 |
| .50 | .54 | -59.78 | 7.92 | 118.86 | .07 | 63.41 | .62 | -35.87 |
| .60 | .47 | -68.54 | 7.20 | 111.69 | .08 | 61.89 | .56 | -38.30 |
| .70 | .41 | -75.97 | 6.55 | 105.17 | .09 | 61.08 | .51 | -39.59 |
| .80 | .35 | -82.95 | 5.99 | 99.70 | .10 | 60.63 | .47 | -40.79 |
| .90 | .31 | -89.34 | 5.47 | 94.96 | .11 | 60.13 | .44 | -41.55 |
| 1.00 | .28 | -95.57 | 5.05 | 90.71 | .12 | 59.77 | .41 | -42.06 |
| 1.10 | .25 | -102.01 | 4.67 | 86.94 | .13 | 59.22 | .38 | -42.76 |
| 1.20 | .23 | -108.52 | 4.35 | 83.30 | .14 | 58.88 | .36 | -43.16 |
| 1.30 | .21 | -115.80 | 4.07 | 80.07 | .15 | 58.01 | .34 | -43.71 |
| 1.40 | .20 | -122.99 | 3.82 | 76.85 | .16 | 57.68 | .32 | -44.42 |
| 1.50 | .18 | -130.79 | 3.60 | 73.93 | .16 | 56.83 | .30 | -45.15 |
| 1.60 | .18 | -138.76 | 3.41 | 71.07 | .17 | 56.28 | .28 | -45.88 |
| 1.70 | .17 | -146.39 | 3.24 | 68.27 | .18 | 55.32 | .27 | -46.69 |
| 1.80 | .17 | -154.38 | 3.09 | 65.56 | .19 | 54.45 | .25 | -47.67 |
| 1.90 | .18 | -161.58 | 2.95 | 63.00 | .20 | 53.52 | .23 | -48.82 |
| 2.00 | .18 | -168.80 | 2.83 | 60.37 | .21 | 52.64 | .21 | -49.56 |
| 2.10 | .18 | -175.19 | 2.72 | 57.83 | .22 | 51.72 | .20 | -51.08 |
| 2.20 | .19 | 178.38 | 2.61 | 55.48 | .23 | 50.71 | .18 | -52.53 |
| 2.30 | .20 | 173.15 | 2.51 | 53.00 | .24 | 49.69 | .17 | -53.99 |
| 2.40 | .21 | 168.10 | 2.42 | 50.71 | .25 | 48.71 | .15 | -55.88 |
| 2.50 | .22 | 163.35 | 2.35 | 48.33 | .26 | 47.65 | .13 | -58.20 |
| 2.60 | .24 | 159.17 | 2.27 | 45.94 | .26 | 46.48 | .12 | -60.77 |
| 2.70 | .25 | 155.13 | 2.20 | 43.64 | .27 | 45.46 | .10 | -63.87 |
| 2.80 | .26 | 151.66 | 2.13 | 41.53 | .28 | 44.18 | .08 | -69.81 |
| 2.90 | .28 | 148.18 | 2.08 | 36.18 | .29 | 42.92 | .07 | -75.78 |
| 3.00 | .29 | 145.87 | 2.02 | 37.27 | .30 | 41.79 | .05 | -87.46 |

S PARAMETER Q2 $V_{CE} = 2 \text{ V}$, $I_C = 7 \text{ mA}$, $Z_0 = 50 \Omega$

| FREQUENCY GHz | S ₁₁ | | S ₂₁ | | S ₁₂ | | S ₂₂ | |
|------------------|-----------------|---------|-----------------|--------|-----------------|-------|-----------------|--------|
| | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. |
| .10 | .82 | -16.31 | 13.83 | 158.85 | .02 | 80.20 | .92 | -14.08 |
| .20 | .73 | -31.08 | 12.52 | 143.87 | .04 | 72.60 | .81 | -24.73 |
| .30 | .62 | -44.88 | 11.48 | 131.26 | .05 | 68.63 | .70 | -31.03 |
| .40 | .52 | -56.37 | 10.28 | 120.77 | .06 | 66.33 | .61 | -35.17 |
| .50 | .43 | -65.51 | 9.08 | 112.24 | .07 | 65.41 | .55 | -37.29 |
| .60 | .37 | -73.22 | 8.02 | 105.64 | .08 | 64.65 | .49 | -38.81 |
| .70 | .31 | -79.68 | 7.15 | 99.96 | .09 | 64.16 | .45 | -39.42 |
| .80 | .27 | -85.85 | 6.43 | 95.22 | .10 | 63.84 | .41 | -39.69 |
| .90 | .24 | -91.96 | 5.83 | 91.06 | .11 | 63.27 | .38 | -40.33 |
| 1.00 | .21 | -97.97 | 5.33 | 87.23 | .12 | 63.10 | .36 | -40.45 |
| 1.10 | .19 | -104.32 | 4.91 | 83.95 | .13 | 62.37 | .34 | -40.77 |
| 1.20 | .17 | -111.26 | 4.56 | 80.63 | .14 | 61.78 | .32 | -40.91 |
| 1.30 | .16 | -119.09 | 4.25 | 77.69 | .15 | 60.94 | .30 | -41.30 |
| 1.40 | .15 | -126.82 | 3.98 | 74.75 | .16 | 60.35 | .28 | -41.80 |
| 1.50 | .14 | -135.36 | 3.75 | 71.91 | .17 | 59.27 | .27 | -42.41 |
| 1.60 | .14 | -143.98 | 3.54 | 69.32 | .18 | 58.46 | .25 | -43.05 |
| 1.70 | .14 | -152.02 | 3.36 | 66.71 | .19 | 57.56 | .23 | -43.89 |
| 1.80 | .14 | -160.48 | 3.20 | 64.28 | .20 | 56.54 | .22 | -44.59 |
| 1.90 | .15 | -167.52 | 3.06 | 61.81 | .20 | 55.40 | .20 | -45.49 |
| 2.00 | .16 | -174.81 | 2.93 | 59.35 | .21 | 54.51 | .19 | -46.25 |
| 2.10 | .16 | 179.19 | 2.80 | 57.01 | .22 | 53.36 | .17 | -47.28 |
| 2.20 | .17 | 173.23 | 2.69 | 54.64 | .23 | 52.09 | .15 | -48.52 |
| 2.30 | .19 | 168.26 | 2.59 | 52.26 | .24 | 50.84 | .14 | -49.66 |
| 2.40 | .20 | 163.59 | 2.50 | 50.03 | .25 | 49.75 | .12 | -51.03 |
| 2.50 | .21 | 159.22 | 2.42 | 47.84 | .26 | 48.61 | .11 | -53.42 |
| 2.60 | .22 | 155.66 | 2.34 | 45.62 | .27 | 47.35 | .09 | -55.58 |
| 2.70 | .24 | 151.91 | 2.27 | 43.50 | .28 | 46.19 | .07 | -57.80 |
| 2.80 | .25 | 148.68 | 2.20 | 41.24 | .29 | 44.87 | .05 | -63.33 |
| 2.90 | .27 | 145.44 | 2.14 | 39.10 | .30 | 43.57 | .04 | -71.16 |
| 3.00 | .28 | 143.38 | 2.07 | 37.17 | .31 | 42.15 | .02 | -89.77 |

S PARAMETER Q2 $V_{CE} = 2\text{ V}$, $I_c = 10\text{ mA}$, $Z_0 = 50\ \Omega$

| FREQUENCY GHz | S ₁₁ | | S ₂₁ | | S ₁₂ | | S ₂₂ | |
|------------------|-----------------|---------|-----------------|--------|-----------------|-------|-----------------|--------|
| | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. |
| .10 | .75 | -19.94 | 18.04 | 155.05 | .02 | 78.63 | .88 | -16.88 |
| .20 | .63 | -37.17 | 15.75 | 137.91 | .03 | 72.31 | .75 | -27.99 |
| .30 | .50 | -51.43 | 13.66 | 124.24 | .04 | 69.65 | .63 | -33.45 |
| .40 | .40 | -61.93 | 11.63 | 113.99 | .06 | 68.34 | .54 | -36.33 |
| .50 | .33 | -69.47 | 9.93 | 106.39 | .07 | 68.06 | .48 | -37.48 |
| .60 | .28 | -76.10 | 8.60 | 100.66 | .08 | 67.81 | .43 | -38.05 |
| .70 | .24 | -81.76 | 7.55 | 95.75 | .09 | 67.13 | .40 | -38.12 |
| .80 | .21 | -87.66 | 6.74 | 91.57 | .10 | 66.95 | .37 | -38.22 |
| .90 | .18 | -93.58 | 6.07 | 87.88 | .11 | 66.28 | .34 | -38.12 |
| 1.00 | .16 | -99.63 | 5.53 | 84.54 | .12 | 65.72 | .32 | -38.04 |
| 1.10 | .14 | -106.61 | 5.07 | 81.36 | .13 | 65.07 | .30 | -38.26 |
| 1.20 | .13 | -113.93 | 4.70 | 78.47 | .14 | 64.27 | .29 | -38.23 |
| 1.30 | .12 | -122.95 | 4.38 | 75.61 | .15 | 63.38 | .27 | -38.44 |
| 1.40 | .12 | -131.42 | 4.09 | 72.98 | .16 | 62.56 | .25 | -38.92 |
| 1.50 | .11 | -140.96 | 3.85 | 70.36 | .17 | 61.30 | .24 | -39.44 |
| 1.60 | .12 | -150.17 | 3.64 | 68.00 | .18 | 60.41 | .22 | -39.88 |
| 1.70 | .12 | -158.80 | 3.45 | 65.54 | .19 | 59.28 | .21 | -40.33 |
| 1.80 | .12 | -167.29 | 3.27 | 63.09 | .20 | 58.03 | .19 | -40.98 |
| 1.90 | .13 | -174.00 | 3.13 | 60.80 | .21 | 56.82 | .18 | -41.90 |
| 2.00 | .14 | 179.16 | 2.99 | 58.43 | .22 | 55.73 | .16 | -42.20 |
| 2.10 | .15 | 173.55 | 2.86 | 56.12 | .23 | 54.42 | .15 | -43.12 |
| 2.20 | .16 | 168.05 | 2.76 | 53.85 | .24 | 53.25 | .13 | -43.66 |
| 2.30 | .17 | 163.79 | 2.66 | 51.62 | .25 | 51.73 | .12 | -44.54 |
| 2.40 | .19 | 159.55 | 2.56 | 49.61 | .26 | 50.61 | .10 | -45.17 |
| 2.50 | .20 | 155.56 | 2.48 | 47.37 | .27 | 49.39 | .08 | -46.33 |
| 2.60 | .21 | 152.29 | 2.38 | 45.19 | .28 | 47.95 | .07 | -46.51 |
| 2.70 | .23 | 148.78 | 2.31 | 42.99 | .29 | 46.76 | .05 | -47.10 |
| 2.80 | .24 | 146.04 | 2.24 | 40.81 | .30 | 45.28 | .03 | -50.69 |
| 2.90 | .26 | 143.20 | 2.18 | 38.94 | .31 | 43.89 | .01 | -48.82 |
| 3.00 | .27 | 141.08 | 2.11 | 36.88 | .31 | 42.38 | 0.00 | 134.74 |

S PARAMETER Q2 $V_{CE} = 2 \text{ V}$, $I_C = 20 \text{ mA}$, $Z_0 = 50 \Omega$

| FREQUENCY GHz | S ₁₁ | | S ₂₁ | | S ₁₂ | | S ₂₂ | |
|------------------|-----------------|---------|-----------------|--------|-----------------|-------|-----------------|--------|
| | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. |
| .10 | .56 | -29.15 | 27.12 | 146.32 | .02 | 77.78 | .80 | -21.74 |
| .20 | .41 | -48.92 | 20.90 | 125.74 | .03 | 74.05 | .63 | -31.76 |
| .30 | .31 | -60.35 | 16.10 | 113.19 | .04 | 72.89 | .51 | -34.75 |
| .40 | .24 | -68.27 | 12.87 | 104.89 | .05 | 73.12 | .44 | -35.38 |
| .50 | .19 | -74.29 | 10.65 | 98.93 | .06 | 72.74 | .39 | -34.92 |
| .60 | .16 | -80.26 | 9.05 | 94.42 | .07 | 72.28 | .36 | -34.40 |
| .70 | .14 | -85.96 | 7.87 | 90.42 | .08 | 71.80 | .33 | -33.68 |
| .80 | .12 | -92.36 | 6.97 | 86.91 | .09 | 71.03 | .31 | -33.35 |
| .90 | .11 | -99.97 | 6.25 | 83.77 | .11 | 70.29 | .29 | -33.01 |
| 1.00 | .10 | -107.48 | 5.67 | 80.84 | .12 | 69.37 | .28 | -32.76 |
| 1.10 | .09 | -116.81 | 5.19 | 78.17 | .13 | 68.41 | .26 | -32.72 |
| 1.20 | .08 | -126.82 | 4.79 | 75.44 | .14 | 67.25 | .25 | -32.69 |
| 1.30 | .08 | -138.28 | 4.46 | 73.03 | .15 | 66.21 | .24 | -32.69 |
| 1.40 | .08 | -148.91 | 4.17 | 70.45 | .16 | 65.13 | .22 | -33.03 |
| 1.50 | .09 | -159.16 | 3.92 | 68.12 | .17 | 63.75 | .21 | -33.54 |
| 1.60 | .09 | -168.23 | 3.69 | 65.84 | .18 | 62.57 | .20 | -33.82 |
| 1.70 | .10 | -175.51 | 3.50 | 63.56 | .19 | 61.27 | .18 | -34.18 |
| 1.80 | .11 | 177.57 | 3.33 | 61.31 | .20 | 59.98 | .17 | -34.31 |
| 1.90 | .12 | 172.34 | 3.17 | 59.18 | .21 | 58.56 | .16 | -34.89 |
| 2.00 | .13 | 167.06 | 3.03 | 56.95 | .22 | 57.22 | .14 | -34.48 |
| 2.10 | .15 | 163.12 | 2.91 | 54.84 | .23 | 55.75 | .13 | -34.89 |
| 2.20 | .16 | 158.95 | 2.79 | 52.71 | .24 | 54.34 | .11 | -34.41 |
| 2.30 | .17 | 155.66 | 2.68 | 50.45 | .25 | 53.02 | .09 | -33.91 |
| 2.40 | .19 | 152.47 | 2.58 | 48.31 | .26 | 51.60 | .08 | -32.52 |
| 2.50 | .20 | 149.55 | 2.50 | 46.34 | .27 | 50.20 | .06 | -30.22 |
| 2.60 | .22 | 146.94 | 2.42 | 44.20 | .28 | 48.59 | .05 | -25.48 |
| 2.70 | .23 | 144.10 | 2.33 | 42.05 | .29 | 47.38 | .03 | -14.13 |
| 2.80 | .25 | 141.69 | 2.26 | 40.12 | .30 | 45.92 | .02 | 4.75 |
| 2.90 | .26 | 139.23 | 2.20 | 38.08 | .31 | 44.36 | .02 | 62.68 |
| 3.00 | .28 | 137.58 | 2.13 | 35.99 | .32 | 42.85 | .03 | 93.61 |

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