NEC

# SILICON TRANSISTOR
# 2SC5177

## NPN EPITAXIAL SILICON TRANSISTOR IN MINI-MOLD PACKAGE FOR LOW-NOISE MICROWAVE AMPLIFICATION

### FEATURES

- Low Current Consumption and High Gain
  $|S_{21e}|^2$ = 9.0 dB TYP. @ $V_{CE}$ = 2 V, $I_C$ = 7 mA, f = 2 GHz
  $|S_{21e}|^2$ = 8.5 dB TYP. @ $V_{CE}$ = 1 V, $I_C$ = 5 mA, f = 2 GHz
- Mini-Mold package
  EIAJ: SC-59

### ORDERING INFORMATION

| PART NUMBER | QUANTITY | ARRANGEMENT |
|---|---|---|
| 2SC5177-T1 | 3 000 units/reel | Embossed tape, 8 mm wide, pin No. 3 (collector) facing the perforations |
| 2SC5177-T2 | 3 000 units/reel | Embossed tape, 8 mm wide, pins No. 1 (emitter) and No. 2 (base) facing the perforations |

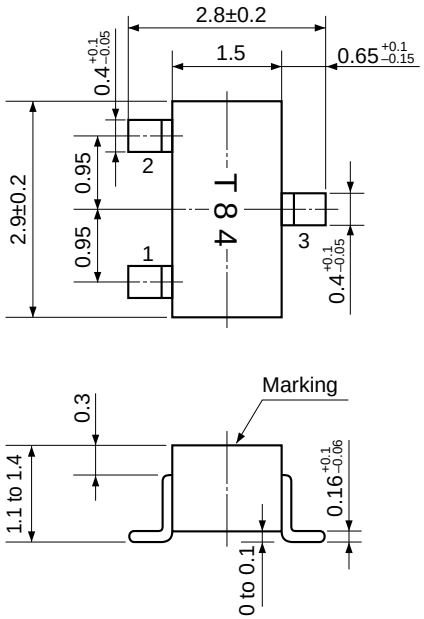
**Remark** Contact your NEC sales representatives to order samples for evaluation (available in batches of 50).

### ABSOLUTE MAXIMUM RATINGS ($T_A$ = 25 °C)

| | | | |
|---|---|---|---|
| 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 | $I_C$ | 10 | mA |
| Total Power Dissipation | $P_T$ | 30 | mW |
| Junction Temperature | $T_j$ | 150 | °C |
| Storage Temperature | $T_{stg}$ | –65 to +150 | °C |

### PACKAGE DIMENSIONS

(Units: mm)




**PIN CONNECTIONS**

1. Emitter
2. Base
3. Collector

**CAUTION;** This transistor uses high-frequency technology. Be careful not to allow excessive current to flow through the transistor, including static electricity.

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## ELECTRICAL CHARACTERISTICS ($T_A$ = 25 °C)

| PARAMETER | SYMBOL | MIN. | TYP. | MAX. | UNIT | CONDITIONS |
|---|---|---|---|---|---|---|
| Collector Cutoff Current | $I_{CBO}$ | | | 100 | nA | $V_{CB}$ = 5 V, $I_E$ = 0 |
| Emitter Cutoff Current | $I_{EBO}$ | | | 100 | nA | $V_{EB}$ = 1 V, $I_C$ = 0 |
| DC Current Gain | $h_{FE}$ | 70 | | 140 | | $V_{CE}$ = 2 V, $I_C$ = 7 mA***1** |
| Insertion Power Gain (1) | $\|S_{21e}\|^2$ | 7.5 | 9 | | dB | $V_{CE}$ = 2 V, $I_C$ = 7 mA, f = 2 GHz |
| Insertion Power Gain (2) | $\|S_{21e}\|^2$ | 7 | 8.5 | | dB | $V_{CE}$ = 1 V, $I_C$ = 5 mA, f = 2 GHz |
| Noise Figure (1) | NF | | 1.5 | 2.0 | dB | $V_{CE}$ = 2 V, $I_C$ = 3 mA, f = 2 GHz |
| Noise Figure (2) | NF | | 1.5 | 2.0 | dB | $V_{CE}$ = 1 V, $I_C$ = 3 mA, f = 2 GHz |
| Gain Bandwidth Product (1) | $f_T$ | 10 | 13 | | GHz | $V_{CE}$ = 2 V, $I_C$ = 7 mA, f = 2 GHz |
| Gain Bandwidth Product (2) | $f_T$ | 8.5 | 12 | | GHz | $V_{CE}$ = 1 V, $I_C$ = 5 mA, f = 2 GHz |
| Feedback Capacitance | $C_{re}$ | | 0.5 | 0.6 | pF | $V_{CB}$ = 2 V, $I_E$ = 0 mA, f = 1 MHz***2** |

***1:** Measured with pulses: Pulse width ≤ 350 $\mu$s, duty cycle ≤ 2 %, pulsed.

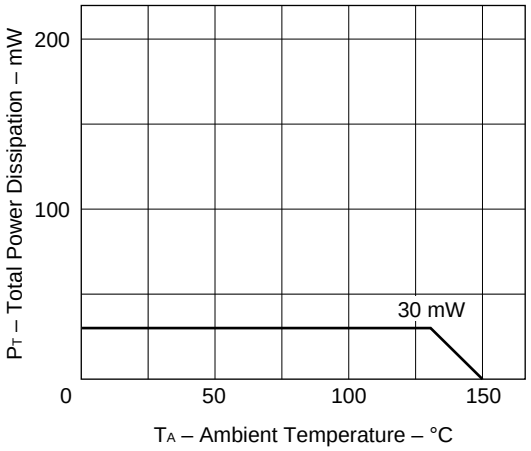
***2:** Measured with a three-terminal bridge. The emitter and case terminal are connected to the guard terminal of the bridge.

### $h_{FE}$ Class

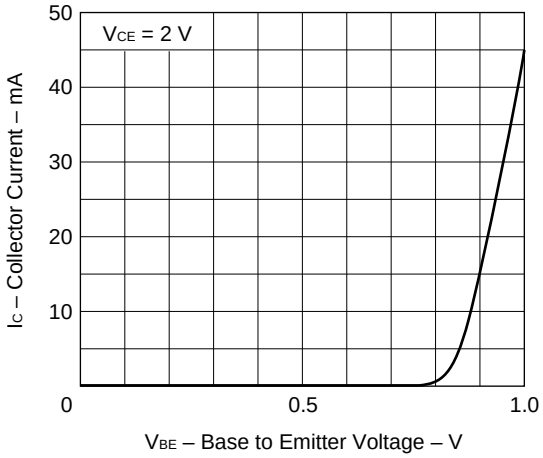
| Class | FB |
|---|---|
| Marking | T84 |
| $h_{FE}$ | 70 to 140 |

## CHARACTERISTICS CURVES ($T_A$ = 25 °C)

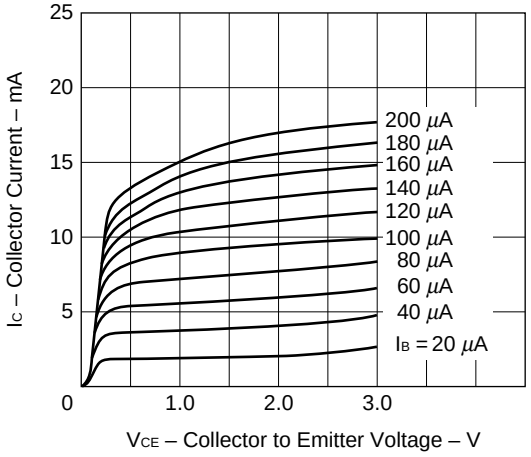
TOTAL POWER DISSIPATION vs.
AMBIENT TEMPERATURE



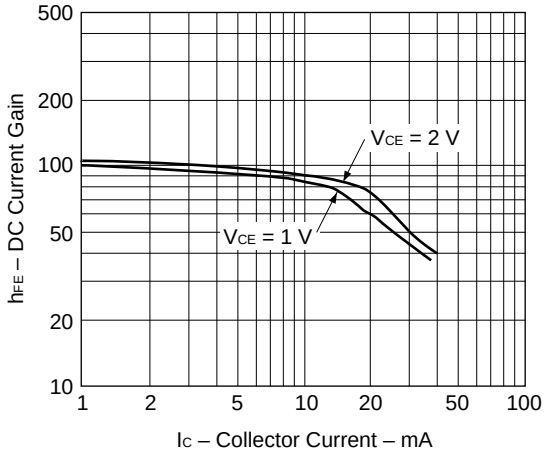

COLLECTOR CURRENT vs.
BASE TO EMITTER VOLTAGE



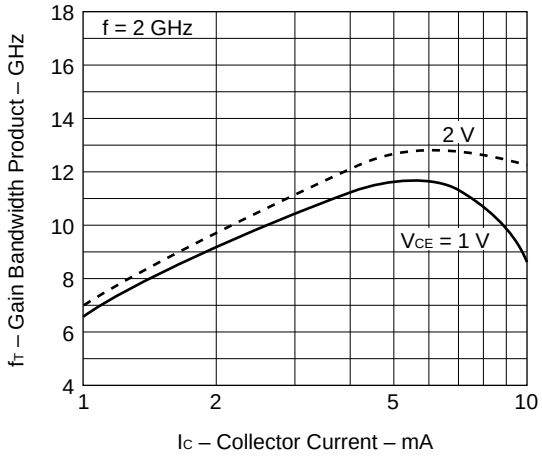

COLLECTOR CURRENT vs.
COLLECTOR TO EMITTER VOLTAGE



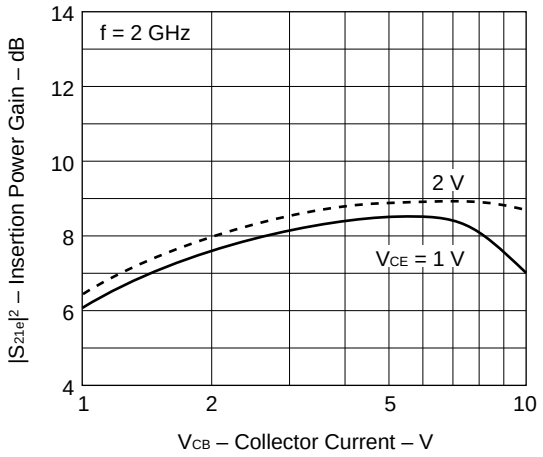

DC CURRENT GAIN vs.
COLLECTOR CURRENT



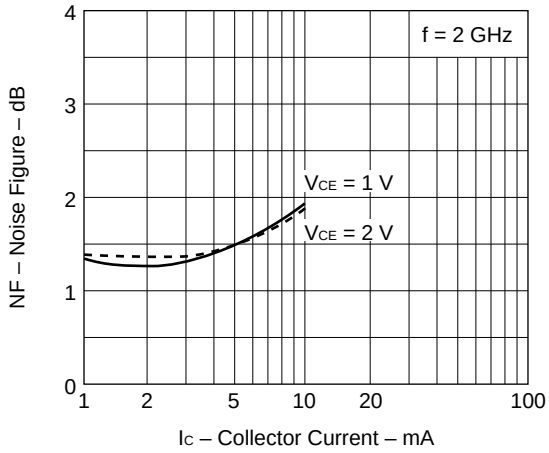

GAIN BANDWIDTH PRODUCT vs.
COLLECTOR CURRENT



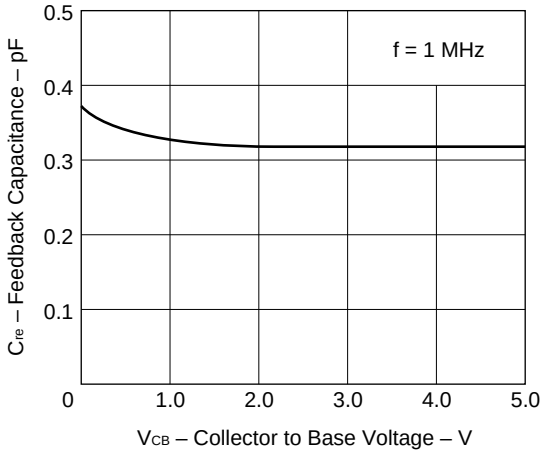

INSERTION POWER GAIN vs.
COLLECTOR CURRENT



NOISE FIGURE vs.
COLLECTOR CURRENT




FEEDBACK CAPACITANCE vs.
COLLECTOR TO BASE VOLTAGE



## S-PARAMETER

$V_{CE}$ = 1 V, $I_C$ = 1 mA, $Z_O$ = 50 Ω

| FREQUENCY | S11 | | S21 | | S12 | | S22 | |
|---|---|---|---|---|---|---|---|---|
| (MHz) | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG |
| 200.00 | 0.967 | –7.9 | 2.211 | 173.0 | 0.047 | 87.2 | 0.999 | –6.2 |
| 400.00 | 0.966 | –16.2 | 2.243 | 165.3 | 0.085 | 82.9 | 1.000 | –12.6 |
| 600.00 | 0.954 | –24.5 | 2.306 | 157.4 | 0.120 | 72.1 | 0.980 | –19.4 |
| 800.00 | 0.924 | –33.4 | 2.399 | 147.7 | 0.158 | 65.6 | 0.962 | –27.4 |
| 1000.00 | 0.392 | –43.7 | 2.444 | 137.3 | 0.193 | 59.3 | 0.929 | –34.2 |
| 1200.00 | 0.312 | –53.9 | 2.446 | 126.1 | 0.222 | 52.8 | 0.890 | –41.0 |
| 1400.00 | 0.756 | –62.4 | 2.389 | 116.2 | 0.247 | 47.4 | 0.822 | –48.2 |
| 1600.00 | 0.673 | –71.9 | 2.251 | 105.6 | 0.260 | 42.2 | 0.753 | –52.8 |
| 1800.00 | 0.590 | –79.0 | 2.210 | 97.2 | 0.267 | 37.4 | 0.688 | –59.5 |
| 2000.00 | 0.543 | –87.9 | 2.085 | 89.2 | 0.283 | 36.0 | 0.645 | –63.9 |
| 2200.00 | 0.460 | –92.7 | 1.978 | 81.7 | 0.231 | 32.8 | 0.596 | –67.5 |
| 2400.00 | 0.410 | –101.7 | 1.917 | 74.6 | 0.293 | 30.6 | 0.548 | –71.3 |
| 2600.00 | 0.347 | –105.9 | 1.860 | 68.4 | 0.281 | 28.6 | 0.518 | –74.7 |
| 2800.00 | 0.277 | –115.6 | 1.740 | 62.4 | 0.309 | 29.9 | 0.475 | –76.9 |
| 3000.00 | 0.224 | –127.1 | 1.725 | 56.4 | 0.312 | 26.6 | 0.465 | –80.4 |

$V_{CE}$ = 1 V, $I_C$ = 3 mA, $Z_O$ = 50 Ω

| FREQUENCY | S11 | | S21 | | S12 | | S22 | |
|---|---|---|---|---|---|---|---|---|
| (MHz) | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG |
| 200.00 | 0.951 | –10.3 | 3.773 | 171.8 | 0.043 | 85.3 | 0.993 | –8.0 |
| 400.00 | 0.942 | –20.9 | 3.848 | 163.1 | 0.081 | 78.7 | 0.981 | –16.7 |
| 600.00 | 0.918 | –32.2 | 3.961 | 153.6 | 0.123 | 64.6 | 0.951 | –26.1 |
| 800.00 | 0.858 | –44.8 | 4.054 | 142.0 | 0.146 | 58.8 | 0.904 | –35.4 |
| 1000.00 | 0.794 | –58.7 | 4.047 | 129.6 | 0.182 | 54.4 | 0.844 | –45.0 |
| 1200.00 | 0.682 | –71.1 | 3.898 | 117.2 | 0.198 | 49.9 | 0.762 | –52.8 |
| 1400.00 | 0.579 | –83.1 | 3.645 | 106.5 | 0.209 | 44.8 | 0.672 | –59.4 |
| 1600.00 | 0.466 | –92.7 | 3.335 | 95.7 | 0.221 | 43.3 | 0.586 | –63.9 |
| 1800.00 | 0.381 | –102.8 | 3.118 | 87.5 | 0.240 | 41.5 | 0.518 | –69.5 |
| 2000.00 | 0.324 | –108.9 | 2.843 | 80.0 | 0.211 | 41.6 | 0.471 | –70.8 |
| 2200.00 | 0.258 | –114.7 | 2.620 | 73.4 | 0.249 | 40.9 | 0.426 | –72.8 |
| 2400.00 | 0.211 | –123.8 | 2.463 | 67.3 | 0.255 | 40.8 | 0.398 | –73.7 |
| 2600.00 | 0.154 | –125.2 | 2.294 | 61.9 | 0.276 | 39.2 | 0.367 | –75.4 |
| 2800.00 | 0.106 | –142.8 | 2.148 | 56.8 | 0.289 | 41.1 | 0.336 | –77.6 |
| 3000.00 | 0.090 | –176.6 | 2.075 | 51.3 | 0.298 | 36.0 | 0.313 | –79.4 |

$V_{CE}$ = 1 V, $I_C$ = 5 mA, $Z_O$ = 50 Ω

| FREQUENCY | S11 | | S21 | | S12 | | S22 | |
|---|---|---|---|---|---|---|---|---|
| (MHz) | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG |
| 200.00 | 0.918 | –12.7 | 5.022 | 168.4 | 0.042 | 89.0 | 0.977 | –10.1 |
| 400.00 | 0.894 | –25.1 | 4.958 | 156.8 | 0.086 | 77.0 | 0.958 | –19.7 |
| 600.00 | 0.839 | –38.5 | 4.883 | 145.2 | 0.112 | 70.4 | 0.898 | –30.0 |
| 800.00 | 0.761 | –51.4 | 4.751 | 132.9 | 0.148 | 59.8 | 0.831 | –39.3 |
| 1000.00 | 0.673 | –65.4 | 4.510 | 120.6 | 0.164 | 54.7 | 0.746 | –48.4 |
| 1200.00 | 0.554 | –78.5 | 4.205 | 109.2 | 0.187 | 46.4 | 0.668 | –55.7 |
| 1400.00 | 0.462 | –89.4 | 3.840 | 99.5 | 0.196 | 45.5 | 0.585 | –61.2 |
| 1600.00 | 0.377 | –98.4 | 3.467 | 90.0 | 0.202 | 48.7 | 0.507 | –64.1 |
| 1800.00 | 0.297 | –106.9 | 3.209 | 82.7 | 0.215 | 46.7 | 0.457 | –67.7 |
| 2000.00 | 0.239 | –114.7 | 2.928 | 75.9 | 0.218 | 42.5 | 0.418 | –69.0 |
| 2200.00 | 0.199 | –121.0 | 2.670 | 69.9 | 0.230 | 47.0 | 0.383 | –71.5 |
| 2400.00 | 0.157 | –135.0 | 2.518 | 64.1 | 0.252 | 45.9 | 0.354 | –72.7 |
| 2600.00 | 0.090 | –147.9 | 2.357 | 59.5 | 0.262 | 41.8 | 0.310 | –73.5 |
| 2800.00 | 0.076 | –175.4 | 2.197 | 54.3 | 0.287 | 42.4 | 0.288 | –79.4 |
| 3000.00 | 0.082 | 141.5 | 2.113 | 49.4 | 0.312 | 43.6 | 0.317 | –78.3 |

$V_{CE}$ = 1 V, $I_C$ = 7 mA, $Z_O$ = 50 Ω

| FREQUENCY | S11 | | S21 | | S12 | | S22 | |
|---|---|---|---|---|---|---|---|---|
| (MHz) | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG |
| 200.00 | 0.820 | –20.3 | 8.814 | 155.7 | 0.042 | 81.2 | 0.926 | –15.3 |
| 400.00 | 0.698 | –37.1 | 7.520 | 136.2 | 0.076 | 72.4 | 0.814 | –27.1 |
| 600.00 | 0.576 | –48.6 | 6.310 | 121.8 | 0.097 | 64.5 | 0.699 | –34.5 |
| 800.00 | 0.463 | –57.4 | 5.368 | 109.9 | 0.120 | 63.5 | 0.618 | –39.9 |
| 1000.00 | 0.380 | –66.0 | 4.606 | 100.3 | 0.135 | 62.2 | 0.558 | –43.5 |
| 1200.00 | 0.299 | –73.4 | 4.049 | 92.5 | 0.160 | 58.3 | 0.502 | –46.4 |
| 1400.00 | 0.255 | –77.0 | 3.575 | 85.9 | 0.185 | 56.5 | 0.463 | –49.6 |
| 1600.00 | 0.207 | –83.0 | 3.193 | 79.0 | 0.195 | 55.5 | 0.421 | –51.0 |
| 1800.00 | 0.165 | –88.7 | 2.942 | 74.1 | 0.220 | 56.4 | 0.400 | –54.4 |
| 2000.00 | 0.131 | –95.4 | 2.692 | 68.9 | 0.230 | 55.1 | 0.370 | –57.1 |
| 2200.00 | 0.087 | –98.6 | 2.474 | 64.0 | 0.248 | 52.1 | 0.367 | –59.5 |
| 2400.00 | 0.074 | –101.7 | 2.316 | 59.4 | 0.264 | 50.7 | 0.319 | –63.8 |
| 2600.00 | 0.029 | –119.5 | 2.220 | 54.9 | 0.287 | 49.1 | 0.314 | –67.5 |
| 2800.00 | 0.030 | 155.8 | 2.061 | 50.7 | 0.310 | 45.8 | 0.285 | –70.4 |
| 3000.00 | 0.070 | 129.1 | 2.014 | 46.9 | 0.337 | 44.0 | 0.303 | –72.3 |

$V_{CE}$ = 2 V, $I_C$ = 1 mA, $Z_O$ = 50 Ω

| FREQUENCY | S11 | | S21 | | S12 | | S22 | |
|---|---|---|---|---|---|---|---|---|
| (MHz) | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG |
| 200.00 | 0.972 | –7.7 | 2.454 | 171.2 | 0.036 | 77.4 | 0.993 | –6.5 |
| 400.00 | 0.947 | –15.5 | 2.452 | 162.4 | 0.079 | 79.0 | 0.991 | –12.6 |
| 600.00 | 0.937 | –23.1 | 2.454 | 154.1 | 0.116 | 74.3 | 0.962 | –19.1 |
| 800.00 | 0.897 | –31.7 | 2.469 | 144.6 | 0.147 | 65.5 | 0.936 | –25.4 |
| 1000.00 | 0.863 | –40.4 | 2.479 | 135.1 | 0.173 | 60.9 | 0.913 | –32.3 |
| 1200.00 | 0.797 | –49.9 | 2.430 | 125.2 | 0.202 | 55.8 | 0.871 | –38.6 |
| 1400.00 | 0.741 | –57.6 | 2.352 | 116.2 | 0.227 | 50.6 | 0.811 | –43.9 |
| 1600.00 | 0.669 | –64.0 | 2.245 | 106.6 | 0.242 | 47.8 | 0.751 | –49.2 |
| 1800.00 | 0.601 | –72.1 | 2.221 | 99.1 | 0.260 | 45.7 | 0.713 | –53.7 |
| 2000.00 | 0.543 | –79.5 | 2.104 | 91.6 | 0.263 | 41.7 | 0.664 | –37.1 |
| 2200.00 | 0.488 | –85.9 | 1.997 | 84.4 | 0.285 | 36.7 | 0.631 | –62.3 |
| 2400.00 | 0.432 | –92.6 | 1.955 | 77.4 | 0.274 | 35.1 | 0.577 | –67.1 |
| 2600.00 | 0.361 | –96.4 | 1.868 | 71.6 | 0.281 | 34.7 | 0.553 | –68.5 |
| 2800.00 | 0.308 | –105.7 | 1.756 | 65.8 | 0.296 | 34.4 | 0.528 | –70.2 |
| 3000.00 | 0.252 | –114.0 | 1.766 | 60.0 | 0.318 | 31.0 | 0.507 | –74.8 |

$V_{CE}$ = 2 V, $I_C$ = 3 mA, $Z_O$ = 50 Ω

| FREQUENCY | S11 | | S21 | | S12 | | S22 | |
|---|---|---|---|---|---|---|---|---|
| (MHz) | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG |
| 200.00 | 0.942 | –11.2 | 4.553 | 168.8 | 0.037 | 77.6 | 0.990 | –8.3 |
| 400.00 | 0.907 | –21.4 | 4.474 | 157.7 | 0.068 | 72.3 | 0.957 | –16.8 |
| 600.00 | 0.866 | –31.7 | 4.378 | 147.2 | 0.112 | 69.4 | 0.922 | –25.2 |
| 800.00 | 0.793 | –42.7 | 4.286 | 136.1 | 0.139 | 61.5 | 0.863 | –33.0 |
| 1000.00 | 0.728 | –52.8 | 4.104 | 125.0 | 0.158 | 58.4 | 0.805 | –40.2 |
| 1200.00 | 0.631 | –63.2 | 3.878 | 114.6 | 0.178 | 54.2 | 0.737 | –47.1 |
| 1400.00 | 0.546 | –71.4 | 3.604 | 105.4 | 0.194 | 52.0 | 0.673 | –42.3 |
| 1600.00 | 0.461 | –79.9 | 3.310 | 96.3 | 0.214 | 48.1 | 0.597 | –55.3 |
| 1800.00 | 0.380 | –86.3 | 3.119 | 88.7 | 0.214 | 46.2 | 0.537 | –60.7 |
| 2000.00 | 0.324 | –91.6 | 2.889 | 82.2 | 0.237 | 45.4 | 0.518 | –62.5 |
| 2200.00 | 0.269 | –96.8 | 2.651 | 75.7 | 0.237 | 45.1 | 0.481 | –65.5 |
| 2400.00 | 0.224 | –102.1 | 2.506 | 70.0 | 0.249 | 44.3 | 0.435 | –67.0 |
| 2600.00 | 0.167 | –103.3 | 2.377 | 64.6 | 0.271 | 42.8 | 0.398 | –70.2 |
| 2800.00 | 0.114 | –113.2 | 2.212 | 59.6 | 0.249 | 40.3 | 0.382 | –71.4 |
| 3000.00 | 0.089 | –137.8 | 2.183 | 54.2 | 0.295 | 37.0 | 0.367 | –71.3 |

$V_{CE}$ = 2 V, $I_C$ = 5 mA, $Z_O$ = 50 Ω

| FREQUENCY | S11 | | S21 | | S12 | | S22 | |
|---|---|---|---|---|---|---|---|---|
| (MHz) | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG |
| 200.00 | 0.900 | –13.9 | 6.328 | 164.5 | 0.034 | 76.0 | 0.971 | –10.9 |
| 400.00 | 0.845 | –26.5 | 5.951 | 150.3 | 0.071 | 77.4 | 0.928 | –20.4 |
| 600.00 | 0.755 | –38.0 | 5.522 | 137.7 | 0.104 | 71.5 | 0.847 | –27.9 |
| 800.00 | 0.671 | –48.1 | 5.092 | 126.0 | 0.131 | 60.9 | 0.786 | –36.3 |
| 1000.00 | 0.580 | –57.1 | 4.654 | 115.2 | 0.147 | 58.7 | 0.707 | –42.7 |
| 1200.00 | 0.501 | –66.9 | 4.234 | 105.6 | 0.159 | 55.4 | 0.644 | –46.6 |
| 1400.00 | 0.418 | –73.5 | 3.826 | 97.8 | 0.172 | 55.4 | 0.575 | –51.2 |
| 1600.00 | 0.347 | –79.9 | 3.476 | 89.9 | 0.189 | 54.7 | 0.528 | –53.3 |
| 1800.00 | 0.289 | –85.8 | 3.230 | 83.5 | 0.215 | 52.0 | 0.488 | –57.2 |
| 2000.00 | 0.253 | –89.0 | 2.979 | 77.9 | 0.222 | 50.3 | 0.438 | –61.4 |
| 2200.00 | 0.200 | –98.0 | 2.740 | 72.1 | 0.226 | 51.4 | 0.432 | –59.5 |
| 2400.00 | 0.159 | –92.3 | 2.586 | 66.7 | 0.255 | 48.4 | 0.393 | –63.7 |
| 2600.00 | 0.121 | –94.3 | 2.450 | 62.0 | 0.269 | 44.1 | 0.365 | –64.5 |
| 2800.00 | 0.063 | –119.9 | 2.277 | 56.8 | 0.293 | 45.8 | 0.345 | –67.6 |
| 3000.00 | 0.026 | –159.8 | 2.219 | 52.6 | 0.299 | 43.6 | 0.345 | –69.4 |

$V_{CE}$ = 2 V, $I_C$ = 7 mA, $Z_O$ = 50 Ω

| FREQUENCY | S11 | | S21 | | S12 | | S22 | |
|---|---|---|---|---|---|---|---|---|
| (MHz) | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG |
| 200.00 | 0.815 | –19.5 | 9.516 | 155.6 | 0.035 | 78.4 | 0.934 | –14.8 |
| 400.00 | 0.696 | –34.3 | 8.064 | 136.1 | 0.064 | 70.8 | 0.828 | –25.2 |
| 600.00 | 0.575 | –44.5 | 6.741 | 121.9 | 0.082 | 63.5 | 0.709 | –32.0 |
| 800.00 | 0.463 | –50.8 | 5.714 | 110.5 | 0.111 | 63.6 | 0.641 | –36.7 |
| 1000.00 | 0.391 | –57.4 | 4.896 | 101.2 | 0.130 | 63.3 | 0.576 | –39.8 |
| 1200.00 | 0.310 | –62.1 | 4.297 | 93.6 | 0.151 | 61.9 | 0.524 | –42.0 |
| 1400.00 | 0.270 | –65.4 | 3.798 | 87.3 | 0.172 | 61.0 | 0.487 | –43.6 |
| 1600.00 | 0.228 | –65.7 | 3.392 | 81.0 | 0.193 | 59.4 | 0.464 | –46.2 |
| 1800.00 | 0.188 | –71.0 | 3.107 | 76.1 | 0.213 | 56.1 | 0.435 | –48.7 |
| 2000.00 | 0.172 | –68.4 | 2.852 | 71.0 | 0.227 | 56.6 | 0.415 | –52.7 |
| 2200.00 | 0.139 | –69.7 | 2.631 | 66.8 | 0.234 | 54.3 | 0.400 | –52.3 |
| 2400.00 | 0.107 | –71.3 | 2.485 | 62.0 | 0.266 | 52.9 | 0.365 | –58.1 |
| 2600.00 | 0.077 | –58.0 | 2.343 | 58.0 | 0.277 | 50.9 | 0.368 | –59.4 |
| 2800.00 | 0.029 | –46.1 | 2.174 | 54.0 | 0.292 | 50.0 | 0.327 | –64.3 |
| 3000.00 | 0.020 | 82.9 | 2.124 | 50.3 | 0.315 | 48.8 | 0.331 | –63.4 |

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