PRELIMINARY DATA SHEET



NEC

SILICON TRANSISTOR

# μPA809T

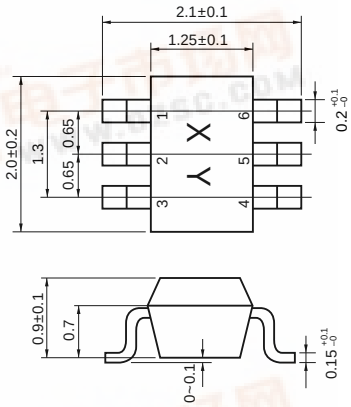
## MICROWAVE LOW NOISE AMPLIFIER
## NPN SILICON EPITAXIAL TRANSISTOR
## (WITH BUILT-IN 2 ELEMENTS) MINI MOLD

### FEATURES

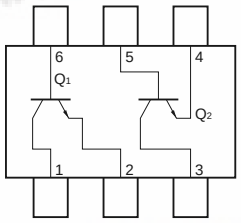
- Low Voltage Operation, Low Phase Distortion
- Low Noise
  NF = 1.5 dB TYP. @$V_{CE}$ = 3 V, $I_C$ = 7 mA, f = 2 GHz
  NF = 1.7 dB TYP. @$V_{CE}$ = 1 V, $I_C$ = 3 mA, f = 2 GHz
- Large Absolute Maximum Collector Current
  $I_C$ = 100 mA
- A Mini Mold Package Adopted
- Built-in 2 Transistors (2 × 2SC5193)

### PACKAGE DRAWINGS

**(Unit: mm)**




### PIN CONFIGURATION (Top View)




**PIN CONNECTIONS**

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

### ORDERING INFORMATION

| PART NUMBER | QUANTITY | PACKING STYLE |
|---|---|---|
| μPA809T | Loose products (50 PCS) | Embossed tape 8 mm wide. Pin 6 (Q1 Base), Pin 5 (Q2 Base), Pin 4 (Q2 Emitter) face to perforation side of the tape. |
| μPA809T-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 °C)

| PARAMETER | SYMBOL | RATING | UNIT |
|---|---|---|---|
| Collector to Base Voltage | $V_{CBO}$ | 9 | V |
| Collector to Emitter Voltage | $V_{CEO}$ | 6 | V |
| Emitter to Base Voltage | $V_{EBO}$ | 2 | V |
| Collector Current | $I_C$ | 100 | mA |
| Total Power Dissipation | $P_T$ | 150 in 1 element<br>200 in 2 elements[Note] | mW |
| Junction Temperature | $T_j$ | 150 | °C |
| Storage Temperature | $T_{stg}$ | –65 to +150 | °C |

**Note** 110 mW must not be exceeded in 1 element.



**This device uses radio frequency technology. Take due precautions to protect it from excessive input levels such as static electricity.**

**The information in this document is subject to change without notice.**

## 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 | $I_{EBO}$ | $V_{EB}$ = 1 V, $I_C$ = 0 | | | 0.1 | μA |
| DC Current Gain | $h_{FE}$ | $V_{CE}$ = 1 V, $I_C$ = 3 mA **Note 1** | 80 | | 160 | |
| Gain Bandwidth Product (1) | $f_T$ | $V_{CE}$ = 1 V, $I_C$ = 3 mA, f = 2 GHz | 4.0 | 4.5 | | GHz |
| Gain Bandwidth Product (2) | $f_T$ | $V_{CE}$ = 3 V, $I_C$ = 20 mA, f = 2 GHz | | 9.0 | | GHz |
| Feed-back Capacitance | $C_{re}$ | $V_{CB}$ = 1 V, $I_E$ = 0, f = 1 MHz **Note 2** | | 0.75 | 0.85 | pF |
| Insertion Power Gain (1) | $\|S_{21}\|^2$ | $V_{CE}$ = 1 V, $I_C$ = 3 mA, f = 2 GHz | 2.5 | 3.5 | | dB |
| Insertion Power Gain (2) | $\|S_{21}\|^2$ | $V_{CE}$ = 3 V, $I_C$ = 20 mA, f = 2 GHz | | 6.5 | | dB |
| Noise Figure (1) | NF | $V_{CE}$ = 1 V, $I_C$ = 3 mA, f = 2 GHz | | 1.7 | 2.5 | dB |
| Noise Figure (2) | NF | $V_{CE}$ = 3 V, $I_C$ = 7 mA, f = 2 GHz | | 1.5 | | dB |
| $h_{FE}$ Ratio | $h_{FE1}/h_{FE2}$ | $V_{CE}$ = 1 V, $I_C$ = 3 mA<br>A smaller value among<br>$h_{FE}$ of $h_{FE1}$ = Q1, Q2<br>A larger value among<br>$h_{FE}$ of $h_{FE2}$ = Q1, Q2 | 0.85 | | | |

**Notes 1.** Pulse Measurement: Pw ≤ 350 μs, Duty cycle ≤ 2 %

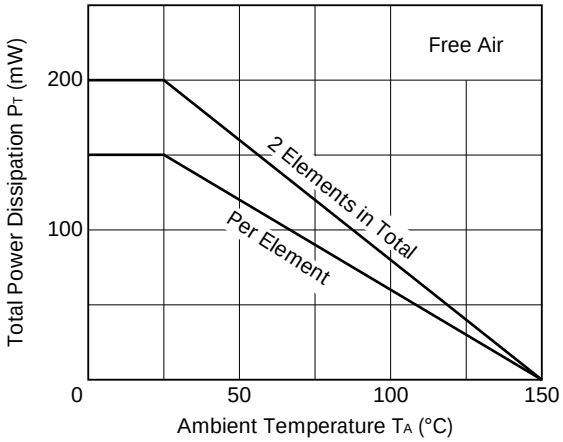
**2.** Measured with 3-pin bridge, emitter and case should be connected to guard pin of bridge.

## $h_{FE}$ CLASSIFICATION

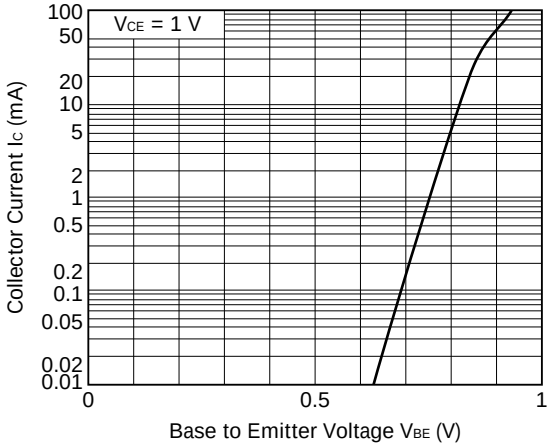
| Rank | KB |
|---|---|
| Marking | T88 |
| $h_{FE}$ Value | 80 to 160 |

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

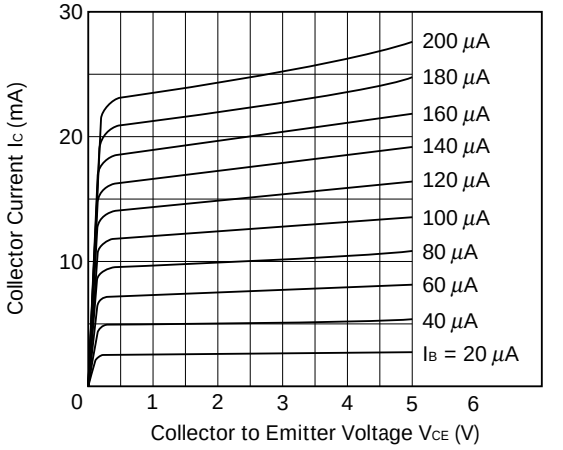
TOTAL POWER DISSIPATION vs.
AMBIENT TEMPERATURE



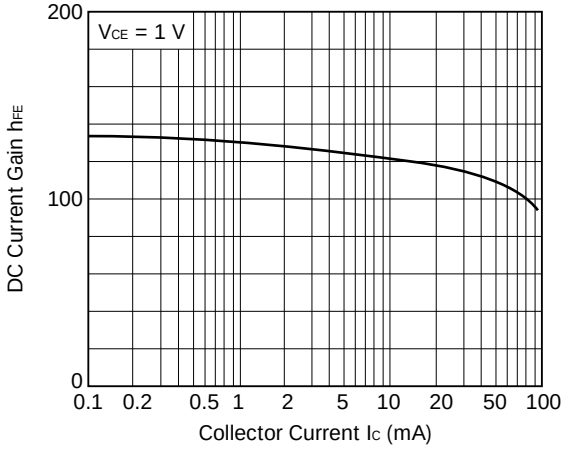

COLLECTOR CURRENT vs.
BASE TO EMITTER VOLTAGE



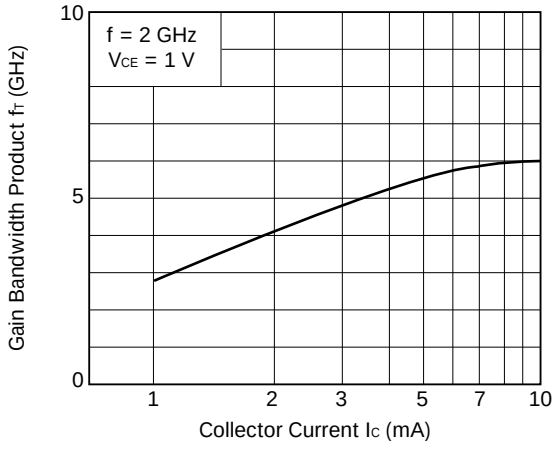

COLLECTOR CURRENT vs.
COLLECTOR TO EMITTER VOLTAGE



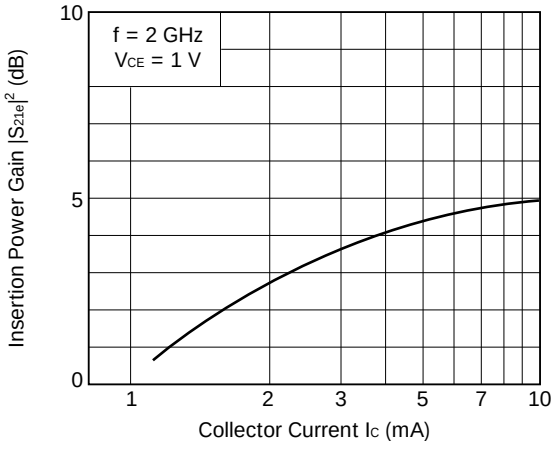

DC CURENT GAIN vs.
COLLECTOR CURRENT



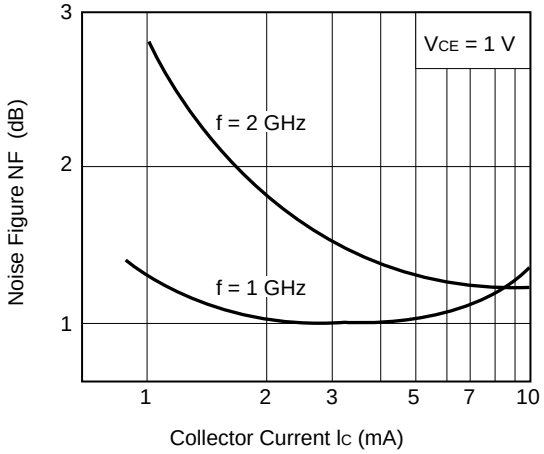

GAIN BANDWIDTH PRODUCT
vs. COLLECTOR CURRENT



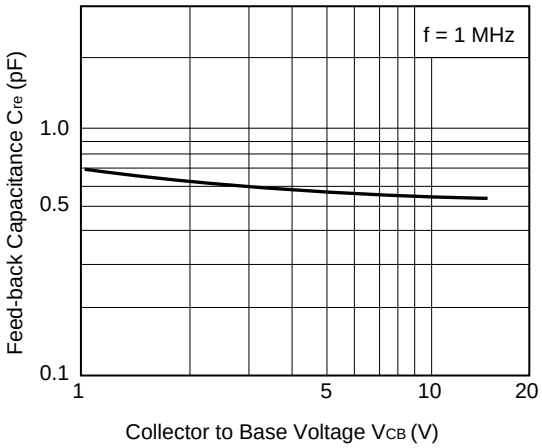

INSERTION GAIN vs.
COLLECTOR CURRENT



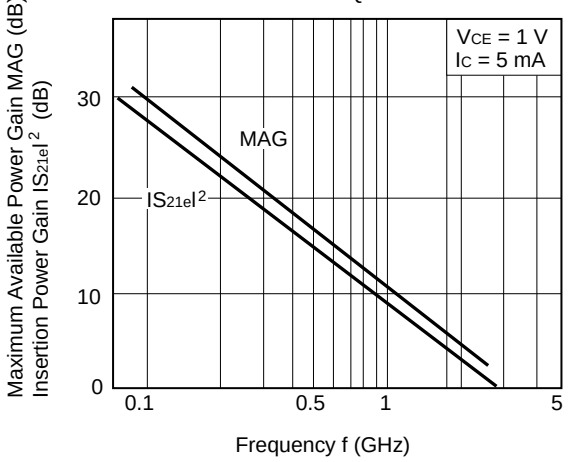
NOISE FIGURE vs.
COLLECTOR CURRENT



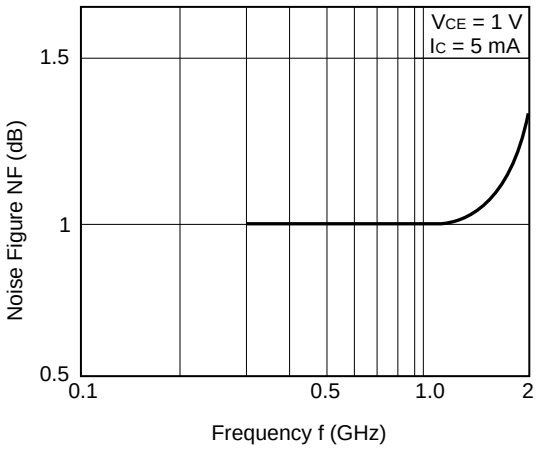

FEED-BACK CAPACITANCE vs.
COLLECTOR TO BASE VOLTAGE




MAXIMUM AVAILABLE GAIN / INSERTION
POWER GAIN vs. FREQUENCY




NOISE FIGURE vs.FREQUENCY



## S-PARAMETERS

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

| FREQUENCY | S11 | | S21 | | S12 | | S22 | |
|---|---|---|---|---|---|---|---|---|
| MHz | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG |
| 100.00 | 0.952 | –18.2 | 3.497 | 166.0 | 0.050 | 74.0 | 0.979 | –8.3 |
| 200.00 | 0.913 | –37.9 | 3.208 | 150.4 | 0.101 | 64.5 | 0.927 | –18.9 |
| 300.00 | 0.871 | –55.6 | 3.048 | 135.4 | 0.141 | 56.5 | 0.855 | –28.2 |
| 400.00 | 0.817 | –68.8 | 2.825 | 124.1 | 0.169 | 49.8 | 0.803 | –33.7 |
| 500.00 | 0.737 | –82.6 | 2.332 | 114.8 | 0.184 | 42.1 | 0.746 | –39.1 |
| 600.00 | 0.657 | –93.4 | 2.236 | 107.2 | 0.196 | 37.7 | 0.691 | –41.0 |
| 700.00 | 0.624 | –103.9 | 2.043 | 99.0 | 0.206 | 33.0 | 0.639 | –45.4 |
| 800.00 | 0.594 | –117.9 | 1.864 | 91.9 | 0.208 | 30.5 | 0.573 | –46.2 |
| 900.00 | 0.560 | –127.1 | 1.715 | 85.0 | 0.208 | 29.0 | 0.538 | –49.5 |
| 1000.00 | 0.544 | –137.0 | 1.593 | 80.3 | 0.203 | 27.8 | 0.494 | –51.7 |
| 1100.00 | 0.527 | –145.1 | 1.458 | 75.3 | 0.200 | 25.6 | 0.478 | –55.7 |
| 1200.00 | 0.534 | –154.5 | 1.391 | 70.9 | 0.195 | 24.4 | 0.450 | –60.1 |
| 1300.00 | 0.554 | –163.9 | 1.258 | 66.7 | 0.195 | 24.1 | 0.426 | –62.4 |
| 1400.00 | 0.566 | –169.0 | 1.200 | 63.5 | 0.194 | 25.6 | 0.409 | –66.3 |
| 1500.00 | 0.547 | –175.2 | 1.185 | 55.1 | 0.199 | 26.0 | 0.406 | –67.7 |
| 1600.00 | 0.523 | 179.3 | 1.176 | 51.3 | 0.201 | 29.6 | 0.392 | –72.4 |
| 1700.00 | 0.540 | 172.6 | 1.129 | 48.8 | 0.198 | 33.0 | 0.375 | –76.0 |
| 1800.00 | 0.530 | 165.2 | 1.109 | 47.4 | 0.199 | 37.3 | 0.370 | –80.9 |
| 1900.00 | 0.559 | 160.8 | 1.028 | 45.2 | 0.200 | 40.0 | 0.365 | –87.1 |
| 2000.00 | 0.571 | 156.2 | 0.981 | 43.6 | 0.203 | 43.2 | 0.364 | –91.0 |

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

| FREQUENCY | S11 | | S21 | | S12 | | S22 | |
|---|---|---|---|---|---|---|---|---|
| MHz | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG |
| 100.00 | 0.864 | –29.3 | 8.784 | 157.7 | 0.050 | 64.3 | 0.927 | –16.5 |
| 200.00 | 0.768 | –37.8 | 7.364 | 136.9 | 0.088 | 56.8 | 0.797 | –34.0 |
| 300.00 | 0.675 | –79.1 | 6.372 | 139.7 | 0.115 | 51.1 | 0.667 | –46.3 |
| 400.00 | 0.584 | –94.9 | 5.374 | 110.1 | 0.130 | 47.2 | 0.568 | –52.1 |
| 500.00 | 0.504 | –110.1 | 4.501 | 102.3 | 0.138 | 44.1 | 0.485 | –55.8 |
| 600.00 | 0.455 | –123.0 | 3.906 | 96.2 | 0.148 | 43.4 | 0.430 | –57.0 |
| 700.00 | 0.428 | –134.7 | 3.298 | 89.7 | 0.156 | 42.3 | 0.380 | –61.3 |
| 800.00 | 0.405 | –145.9 | 2.938 | 84.1 | 0.163 | 42.8 | 0.321 | –63.1 |
| 900.00 | 0.381 | –154.2 | 2.915 | 79.4 | 0.171 | 43.7 | 0.286 | –64.8 |
| 1000.00 | 0.379 | –163.1 | 2.397 | 75.8 | 0.178 | 44.6 | 0.239 | –66.7 |
| 1100.00 | 0.374 | –171.9 | 2.196 | 72.0 | 0.184 | 44.7 | 0.246 | –70.8 |
| 1200.00 | 0.389 | –178.5 | 2.061 | 68.3 | 0.190 | 44.6 | 0.226 | –76.4 |
| 1300.00 | 0.404 | 174.9 | 1.916 | 64.3 | 0.198 | 44.2 | 0.201 | –79.4 |
| 1400.00 | 0.414 | 172.1 | 1.829 | 60.6 | 0.210 | 44.4 | 0.184 | –83.7 |
| 1500.00 | 0.411 | 165.7 | 1.759 | 55.5 | 0.225 | 44.2 | 0.176 | –85.9 |
| 1600.00 | 0.402 | 161.8 | 1.680 | 52.5 | 0.241 | 45.3 | 0.167 | –92.5 |
| 1700.00 | 0.417 | 156.7 | 1.606 | 50.1 | 0.249 | 48.9 | 0.159 | –97.7 |
| 1800.00 | 0.428 | 151.2 | 1.537 | 49.4 | 0.259 | 48.8 | 0.151 | –107.2 |
| 1900.00 | 0.446 | 148.4 | 1.458 | 47.4 | 0.265 | 48.7 | 0.130 | –114.4 |
| 2000.00 | 0.457 | 144.8 | 1.394 | 43.8 | 0.272 | 48.6 | 0.155 | –120.7 |

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

| FREQUENCY | S11 | | S21 | | S12 | | S22 | |
|---|---|---|---|---|---|---|---|---|
| MHz | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG |
| 100.00 | 0.790 | –37.9 | 12.042 | 152.3 | 0.043 | 67.5 | 0.886 | –23.5 |
| 200.00 | 0.672 | –69.2 | 9.515 | 129.2 | 0.079 | 54.7 | 0.708 | –42.2 |
| 300.00 | 0.564 | –91.9 | 7.780 | 113.6 | 0.101 | 51.0 | 0.562 | –55.7 |
| 400.00 | 0.475 | –108.5 | 3.993 | 103.8 | 0.115 | 49.2 | 0.456 | –61.2 |
| 500.00 | 0.415 | –123.8 | 4.959 | 97.3 | 0.124 | 48.6 | 0.374 | –63.8 |
| 600.00 | 0.383 | –137.1 | 4.268 | 92.1 | 0.135 | 49.0 | 0.329 | –64.4 |
| 700.00 | 0.366 | –147.8 | 3.741 | 86.2 | 0.146 | 48.6 | 0.289 | –69.8 |
| 800.00 | 0.331 | –138.3 | 3.313 | 81.3 | 0.156 | 47.4 | 0.235 | –73.5 |
| 900.00 | 0.332 | –166.3 | 2.927 | 77.3 | 0.168 | 50.2 | 0.202 | –75.2 |
| 1000.00 | 0.335 | –174.3 | 2.677 | 74.1 | 0.179 | 51.1 | 0.181 | –76.6 |
| 1100.00 | 0.337 | 177.3 | 2.431 | 70.7 | 0.188 | 50.8 | 0.175 | –81.8 |
| 1200.00 | 0.333 | 172.0 | 2.282 | 67.4 | 0.197 | 50.3 | 0.158 | –90.1 |
| 1300.00 | 0.365 | 166.3 | 2.124 | 63.6 | 0.208 | 49.5 | 0.134 | –95.4 |
| 1400.00 | 0.375 | 164.2 | 2.027 | 59.9 | 0.222 | 48.9 | 0.120 | –101.8 |
| 1500.00 | 0.378 | 158.6 | 1.944 | 55.4 | 0.240 | 48.1 | 0.114 | –106.3 |
| 1600.00 | 0.373 | 155.0 | 1.850 | 52.7 | 0.258 | 48.4 | 0.112 | –116.2 |
| 1700.00 | 0.387 | 150.8 | 1.764 | 50.6 | 0.269 | 49.5 | 0.107 | –128.3 |
| 1800.00 | 0.401 | 146.1 | 1.679 | 50.0 | 0.279 | 50.2 | 0.109 | –137.3 |
| 1900.00 | 0.418 | 143.8 | 1.603 | 48.2 | 0.286 | 50.1 | 0.114 | –144.5 |
| 2000.00 | 0.429 | 140.6 | 1.526 | 46.7 | 0.294 | 49.5 | 0.125 | –150.2 |

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

| FREQUENCY | S11 | | S21 | | S12 | | S22 | |
|---|---|---|---|---|---|---|---|---|
| MHz | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG |
| 100.00 | 0.736 | –44.1 | 14.388 | 148.1 | 0.041 | 61.2 | 0.833 | –28.2 |
| 200.00 | 0.603 | –77.3 | 10.890 | 124.2 | 0.074 | 53.6 | 0.642 | –48.4 |
| 300.00 | 0.494 | –100.6 | 8.181 | 109.3 | 0.094 | 51.9 | 0.497 | –62.1 |
| 400.00 | 0.415 | –117.8 | 6.500 | 100.3 | 0.108 | 51.7 | 0.389 | –68.0 |
| 500.00 | 0.369 | –133.0 | 5.307 | 94.7 | 0.118 | 52.1 | 0.310 | –70.2 |
| 600.00 | 0.350 | –145.9 | 4.558 | 89.8 | 0.132 | 52.9 | 0.271 | –70.5 |
| 700.00 | 0.336 | –155.9 | 3.974 | 84.3 | 0.144 | 52.7 | 0.240 | –77.0 |
| 800.00 | 0.324 | –166.0 | 3.500 | 79.9 | 0.156 | 53.1 | 0.191 | –83.3 |
| 900.00 | 0.309 | –173.7 | 3.096 | 76.3 | 0.169 | 53.8 | 0.158 | –85.9 |
| 1000.00 | 0.314 | 178.7 | 2.819 | 73.3 | 0.183 | 54.2 | 0.141 | –87.1 |
| 1100.00 | 0.319 | 171.0 | 2.583 | 70.1 | 0.193 | 53.7 | 0.139 | –93.2 |
| 1200.00 | 0.335 | 166.5 | 2.407 | 66.9 | 0.204 | 52.9 | 0.128 | –104.6 |
| 1300.00 | 0.347 | 161.6 | 2.235 | 63.3 | 0.215 | 51.8 | 0.106 | –113.9 |
| 1400.00 | 0.336 | 159.6 | 2.137 | 59.8 | 0.231 | 50.8 | 0.093 | –123.2 |
| 1500.00 | 0.362 | 154.5 | 2.032 | 55.5 | 0.250 | 49.7 | 0.093 | –129.3 |
| 1600.00 | 0.359 | 151.2 | 1.932 | 52.9 | 0.268 | 49.5 | 0.098 | –140.1 |
| 1700.00 | 0.373 | 147.4 | 1.845 | 50.9 | 0.280 | 50.4 | 0.102 | –133.9 |
| 1800.00 | 0.388 | 143.2 | 1.756 | 50.5 | 0.291 | 50.7 | 0.110 | –161.6 |
| 1900.00 | 0.404 | 141.0 | 1.676 | 48.7 | 0.299 | 50.5 | 0.116 | –167.2 |
| 2000.00 | 0.415 | 138.1 | 1.597 | 47.5 | 0.307 | 49.6 | 0.130 | –170.3 |

$V_{CE}$ = 1 V, $I_C$ = 10 mA, $Z_O$ = 50 Ω

| FREQUENCY | S11 | | S21 | | S12 | | S22 | |
|---|---|---|---|---|---|---|---|---|
| MHz | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG |
| 100.00 | 0.676 | –49.5 | 16.485 | 144.1 | 0.041 | 59.8 | 0.808 | –31.3 |
| 200.00 | 0.545 | –83.0 | 11.960 | 120.0 | 0.071 | 53.3 | 0.588 | –53.4 |
| 300.00 | 0.442 | –108.8 | 8.726 | 105.9 | 0.090 | 53.3 | 0.443 | –67.7 |
| 400.00 | 0.372 | –126.4 | 6.820 | 97.6 | 0.103 | 54.1 | 0.339 | –73.9 |
| 500.00 | 0.339 | –141.2 | 5.333 | 92.6 | 0.116 | 54.9 | 0.263 | –76.2 |
| 600.00 | 0.328 | –153.6 | 4.754 | 88.1 | 0.130 | 33.9 | 0.229 | –76.4 |
| 700.00 | 0.318 | –162.8 | 4.124 | 82.9 | 0.143 | 55.4 | 0.205 | –84.2 |
| 800.00 | 0.309 | –172.4 | 3.626 | 78.7 | 0.157 | 55.7 | 0.162 | –93.2 |
| 900.00 | 0.295 | –179.8 | 3.201 | 75.3 | 0.171 | 56.3 | 0.131 | –97.4 |
| 1000.00 | 0.303 | 173.2 | 2.922 | 72.6 | 0.186 | 56.4 | 0.115 | –99.3 |
| 1100.00 | 0.310 | 166.1 | 2.674 | 69.6 | 0.198 | 55.7 | 0.118 | –105.7 |
| 1200.00 | 0.326 | 162.2 | 2.480 | 66.5 | 0.209 | 54.5 | 0.113 | –119.6 |
| 1300.00 | 0.336 | 157.7 | 2.312 | 63.1 | 0.221 | 53.1 | 0.096 | –132.9 |
| 1400.00 | 0.345 | 156.0 | 2.205 | 39.5 | 0.237 | 51.9 | 0.089 | –144.2 |
| 1500.00 | 0.333 | 151.3 | 2.100 | 55.5 | 0.257 | 50.6 | 0.091 | –151.0 |
| 1600.00 | 0.351 | 148.1 | 1.989 | 55.0 | 0.276 | 50.2 | 0.101 | –159.3 |
| 1700.00 | 0.360 | 144.8 | 1.904 | 51.0 | 0.230 | 50.9 | 0.111 | –171.4 |
| 1800.00 | 0.380 | 140.9 | 1.804 | 50.7 | 0.300 | 51.0 | 0.122 | –177.0 |
| 1900.00 | 0.396 | 139.0 | 1.724 | 49.0 | 0.307 | 50.7 | 0.129 | 178.5 |
| 2000.00 | 0.407 | 136.0 | 1.642 | 47.6 | 0.315 | 49.7 | 0.143 | 177.0 |

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

| FREQUENCY | S11 | | S21 | | S12 | | S22 | |
|---|---|---|---|---|---|---|---|---|
| MHz | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG |
| 100.00 | 1.003 | –16.7 | 3.418 | 166.9 | 0.029 | 74.7 | 0.989 | –3.6 |
| 200.00 | 0.956 | –32.7 | 3.121 | 154.7 | 0.078 | 64.7 | 0.951 | –14.1 |
| 300.00 | 0.938 | –48.4 | 3.082 | 141.4 | 0.113 | 60.2 | 0.897 | –21.7 |
| 400.00 | 0.895 | –61.8 | 2.931 | 129.6 | 0.138 | 53.4 | 0.857 | –26.1 |
| 500.00 | 0.793 | –75.1 | 2.631 | 120.5 | 0.130 | 46.1 | 0.811 | –30.5 |
| 600.00 | 0.700 | –83.7 | 2.365 | 114.3 | 0.160 | 42.9 | 0.774 | –31.5 |
| 700.00 | 0.671 | –96.0 | 2.189 | 106.3 | 0.171 | 38.2 | 0.735 | –35.8 |
| 800.00 | 0.629 | –108.8 | 1.997 | 98.9 | 0.172 | 34.9 | 0.665 | –35.9 |
| 900.00 | 0.581 | –117.9 | 1.837 | 92.0 | 0.172 | 33.9 | 0.636 | –38.4 |
| 1000.00 | 0.554 | –127.4 | 1.706 | 87.7 | 0.170 | 33.3 | 0.590 | –39.3 |
| 1100.00 | 0.535 | –135.4 | 1.570 | 82.7 | 0.167 | 31.4 | 0.579 | –43.2 |
| 1200.00 | 0.531 | –145.8 | 1.510 | 78.0 | 0.162 | 30.6 | 0.541 | –47.1 |
| 1300.00 | 0.540 | –156.4 | 1.359 | 74.3 | 0.162 | 30.5 | 0.522 | –48.3 |
| 1400.00 | 0.542 | –161.9 | 1.299 | 71.7 | 0.162 | 32.5 | 0.510 | –51.5 |
| 1500.00 | 0.527 | –168.3 | 1.278 | 62.8 | 0.166 | 33.5 | 0.509 | –52.6 |
| 1600.00 | 0.497 | –174.3 | 1.272 | 58.3 | 0.169 | 37.6 | 0.493 | –56.2 |
| 1700.00 | 0.512 | 178.3 | 1.216 | 55.8 | 0.169 | 41.3 | 0.476 | –58.1 |
| 1800.00 | 0.492 | 170.4 | 1.209 | 54.2 | 0.171 | 46.9 | 0.469 | –62.0 |
| 1900.00 | 0.524 | 165.5 | 1.119 | 52.2 | 0.176 | 49.9 | 0.454 | –66.3 |
| 2000.00 | 0.534 | 159.9 | 1.069 | 50.4 | 0.180 | 33.4 | 0.454 | –69.3 |

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

| FREQUENCY | S11 | | S21 | | S12 | | S22 | |
|---|---|---|---|---|---|---|---|---|
| MHz | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG |
| 100.00 | 0.924 | –23.0 | 8.393 | 160.8 | 0.031 | 54.9 | 0.965 | –10.7 |
| 200.00 | 0.830 | –46.1 | 7.259 | 143.7 | 0.070 | 59.2 | 0.964 | –24.0 |
| 300.00 | 0.750 | –65.0 | 6.624 | 128.1 | 0.096 | 55.7 | 0.760 | –34.3 |
| 400.00 | 0.653 | –79.4 | 3.805 | 116.8 | 0.111 | 51.5 | 0.671 | –38.9 |
| 500.00 | 0.548 | –93.1 | 4.720 | 108.8 | 0.119 | 48.5 | 0.599 | –41.3 |
| 600.00 | 0.471 | –104.2 | 4.121 | 103.1 | 0.127 | 47.9 | 0.555 | –41.1 |
| 700.00 | 0.433 | –116.2 | 3.695 | 96.4 | 0.136 | 46.5 | 0.509 | –44.9 |
| 800.00 | 0.397 | –128.3 | 3.302 | 90.5 | 0.141 | 46.3 | 0.441 | –44.6 |
| 900.00 | 0.361 | –136.7 | 2.944 | 85.5 | 0.147 | 47.4 | 0.409 | –43.0 |
| 1000.00 | 0.345 | –146.1 | 2.696 | 82.0 | 0.153 | 48.6 | 0.378 | –44.9 |
| 1100.00 | 0.332 | –155.5 | 2.479 | 77.9 | 0.158 | 48.6 | 0.368 | –48.3 |
| 1200.00 | 0.336 | –164.1 | 2.328 | 74.3 | 0.163 | 48.8 | 0.338 | –52.4 |
| 1300.00 | 0.346 | –172.7 | 2.158 | 70.3 | 0.170 | 48.7 | 0.314 | –52.7 |
| 1400.00 | 0.332 | –177.1 | 2.063 | 67.1 | 0.180 | 49.3 | 0.300 | –54.5 |
| 1500.00 | 0.347 | 176.5 | 1.997 | 61.8 | 0.194 | 49.2 | 0.294 | –55.3 |
| 1600.00 | 0.338 | 171.8 | 1.906 | 58.4 | 0.207 | 50.6 | 0.282 | –58.8 |
| 1700.00 | 0.349 | 165.6 | 1.818 | 56.0 | 0.216 | 52.3 | 0.262 | –60.8 |
| 1800.00 | 0.355 | 139.2 | 1.740 | 55.1 | 0.225 | 54.4 | 0.251 | –64.3 |
| 1900.00 | 0.373 | 155.6 | 1.650 | 53.2 | 0.233 | 53.1 | 0.241 | –68.3 |
| 2000.00 | 0.387 | 131.2 | 1.376 | 31.6 | 0.240 | 55.5 | 0.239 | –72.5 |

$V_{CE}$ = 3 V, $I_C$ = 5 mA, $Z_O$ = 50 Ω

| FREQUENCY | S11 | | S21 | | S12 | | S22 | |
|---|---|---|---|---|---|---|---|---|
| MHz | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG |
| 100.00 | 0.865 | –27.8 | 11.588 | 156.9 | 0.036 | 49.9 | 0.938 | –13.2 |
| 200.00 | 0.742 | –53.4 | 9.364 | 137.4 | 0.066 | 58.5 | 0.805 | –29.3 |
| 300.00 | 0.637 | –73.2 | 8.312 | 121.7 | 0.086 | 53.0 | 0.675 | –40.3 |
| 400.00 | 0.531 | –87.6 | 6.607 | 110.7 | 0.100 | 53.2 | 0.576 | –44.3 |
| 500.00 | 0.438 | –101.3 | 5.519 | 103.7 | 0.109 | 52.0 | 0.500 | –45.6 |
| 600.00 | 0.376 | –113.3 | 4.799 | 98.6 | 0.118 | 52.5 | 0.461 | –44.5 |
| 700.00 | 0.343 | –125.0 | 4.262 | 92.5 | 0.128 | 52.0 | 0.418 | –48.1 |
| 800.00 | 0.315 | –136.9 | 3.784 | 87.3 | 0.135 | 52.5 | 0.357 | –47.9 |
| 900.00 | 0.286 | –145.5 | 3.354 | 83.0 | 0.143 | 53.5 | 0.325 | –47.4 |
| 1000.00 | 0.276 | –154.9 | 3.048 | 79.8 | 0.154 | 54.4 | 0.301 | –46.6 |
| 1100.00 | 0.268 | –164.6 | 2.812 | 76.3 | 0.163 | 54.4 | 0.294 | –50.1 |
| 1200.00 | 0.276 | –172.4 | 2.613 | 73.0 | 0.170 | 54.2 | 0.267 | –54.7 |
| 1300.00 | 0.286 | 179.9 | 2.441 | 69.4 | 0.180 | 53.6 | 0.243 | –54.8 |
| 1400.00 | 0.293 | 173.9 | 2.321 | 63.9 | 0.192 | 53.4 | 0.228 | –56.1 |
| 1500.00 | 0.294 | 169.9 | 2.232 | 61.4 | 0.207 | 52.8 | 0.222 | –57.0 |
| 1600.00 | 0.290 | 165.5 | 2.123 | 58.3 | 0.223 | 53.4 | 0.211 | –61.0 |
| 1700.00 | 0.303 | 160.1 | 2.030 | 56.3 | 0.234 | 54.4 | 0.191 | –63.5 |
| 1800.00 | 0.313 | 154.3 | 1.932 | 53.6 | 0.244 | 55.8 | 0.179 | –67.5 |
| 1900.00 | 0.330 | 151.2 | 1.836 | 53.8 | 0.252 | 56.0 | 0.171 | –71.9 |
| 2000.00 | 0.341 | 147.2 | 1.757 | 52.4 | 0.259 | 55.8 | 0.168 | –77.4 |

$V_{CE}$ = 3 V, $I_C$ = 7 mA, $Z_O$ = 50 Ω

| FREQUENCY | S11 | | S21 | | S12 | | S22 | |
|---|---|---|---|---|---|---|---|---|
| MHz | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG |
| 100.00 | 0.811 | –32.6 | 14.032 | 153.7 | 0.027 | 57.0 | 0.922 | –18.2 |
| 200.00 | 0.668 | –59.1 | 11.239 | 132.2 | 0.063 | 56.7 | 0.752 | –33.9 |
| 300.00 | 0.553 | –79.0 | 8.969 | 116.7 | 0.081 | 55.4 | 0.611 | –44.6 |
| 400.00 | 0.449 | –93.3 | 7.293 | 106.9 | 0.094 | 55.4 | 0.510 | –47.9 |
| 500.00 | 0.370 | –107.1 | 6.039 | 100.6 | 0.103 | 55.3 | 0.435 | –48.1 |
| 600.00 | 0.318 | –119.6 | 5.212 | 93.8 | 0.114 | 56.2 | 0.400 | –46.5 |
| 700.00 | 0.290 | –131.1 | 4.581 | 90.2 | 0.125 | 55.8 | 0.364 | –50.1 |
| 800.00 | 0.268 | –142.9 | 4.057 | 85.5 | 0.134 | 56.2 | 0.305 | –50.1 |
| 900.00 | 0.244 | –151.8 | 3.587 | 81.6 | 0.145 | 57.1 | 0.275 | –49.0 |
| 1000.00 | 0.237 | –161.2 | 3.266 | 78.6 | 0.157 | 57.6 | 0.255 | –47.7 |
| 1100.00 | 0.233 | –170.9 | 3.003 | 75.4 | 0.167 | 57.5 | 0.249 | –51.5 |
| 1200.00 | 0.243 | –178.1 | 2.794 | 72.3 | 0.173 | 57.0 | 0.225 | –56.7 |
| 1300.00 | 0.253 | 174.8 | 2.596 | 68.9 | 0.186 | 56.1 | 0.199 | –56.7 |
| 1400.00 | 0.261 | 171.0 | 2.474 | 65.4 | 0.199 | 55.4 | 0.185 | –37.7 |
| 1500.00 | 0.265 | 165.4 | 2.365 | 61.3 | 0.216 | 54.6 | 0.179 | –38.7 |
| 1600.00 | 0.265 | 161.2 | 2.253 | 58.4 | 0.232 | 54.7 | 0.169 | –63.3 |
| 1700.00 | 0.277 | 156.4 | 2.153 | 56.5 | 0.245 | 55.5 | 0.149 | –66.8 |
| 1800.00 | 0.290 | 151.1 | 2.046 | 56.9 | 0.233 | 56.4 | 0.137 | –71.3 |
| 1900.00 | 0.306 | 148.3 | 1.943 | 54.2 | 0.264 | 56.4 | 0.130 | –76.7 |
| 2000.00 | 0.318 | 144.6 | 1.856 | 52.8 | 0.271 | 53.9 | 0.128 | –83.6 |

$V_{CE}$ = 3 V, $I_C$ = 10 mA, $Z_O$ = 50 Ω

| FREQUENCY | S11 | | S21 | | S12 | | S22 | |
|---|---|---|---|---|---|---|---|---|
| MHz | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG |
| 100.00 | 0.775 | –34.3 | 16.213 | 130.4 | 0.031 | 42.4 | 0.916 | –18.1 |
| 200.00 | 0.609 | –63.8 | 12.257 | 128.4 | 0.037 | 55.3 | 0.712 | –37.2 |
| 300.00 | 0.488 | –83.7 | 9.683 | 115.4 | 0.077 | 56.3 | 0.569 | –47.6 |
| 400.00 | 0.390 | –98.0 | 7.790 | 104.3 | 0.091 | 56.6 | 0.467 | –30.5 |
| 500.00 | 0.321 | –111.7 | 6.396 | 98.4 | 0.101 | 57.6 | 0.394 | –50.4 |
| 600.00 | 0.277 | –124.8 | 5.493 | 93.8 | 0.113 | 58.5 | 0.362 | –48.1 |
| 700.00 | 0.253 | –136.0 | 4.808 | 88.6 | 0.125 | 58.4 | 0.329 | –51.9 |
| 800.00 | 0.236 | –147.8 | 4.252 | 84.3 | 0.135 | 58.4 | 0.273 | –52.2 |
| 900.00 | 0.216 | –157.0 | 3.752 | 80.7 | 0.147 | 59.1 | 0.242 | –50.9 |
| 1000.00 | 0.212 | –166.4 | 3.408 | 77.8 | 0.160 | 59.6 | 0.224 | –49.1 |
| 1100.00 | 0.221 | –176.0 | 3.131 | 74.8 | 0.171 | 59.2 | 0.220 | –53.1 |
| 1200.00 | 0.221 | 177.3 | 2.909 | 71.9 | 0.180 | 58.5 | 0.197 | –59.1 |
| 1300.00 | 0.232 | 170.6 | 2.711 | 68.6 | 0.191 | 57.3 | 0.171 | –59.2 |
| 1400.00 | 0.240 | 167.1 | 2.581 | 65.2 | 0.205 | 56.3 | 0.157 | –60.1 |
| 1500.00 | 0.247 | 161.8 | 2.457 | 61.2 | 0.222 | 55.2 | 0.150 | –61.2 |
| 1600.00 | 0.248 | 158.0 | 2.335 | 58.5 | 0.239 | 55.2 | 0.141 | –66.8 |
| 1700.00 | 0.261 | 153.6 | 2.236 | 56.6 | 0.252 | 53.8 | 0.121 | –71.4 |
| 1800.00 | 0.275 | 148.5 | 2.120 | 56.2 | 0.263 | 56.5 | 0.101 | –77.2 |
| 1900.00 | 0.291 | 146.1 | 2.019 | 54.6 | 0.272 | 56.4 | 0.104 | –83.3 |
| 2000.00 | 0.302 | 142.6 | 1.923 | 53.2 | 0.279 | 56.8 | 0.104 | –91.6 |

[MEMO]

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