Ordering number : ENN7327

NPN Epitaxial Planar Silicon Transistor

# 2SC5648

## UHF to S Band Low-Noise Amplifier and OSC Applications

## Features

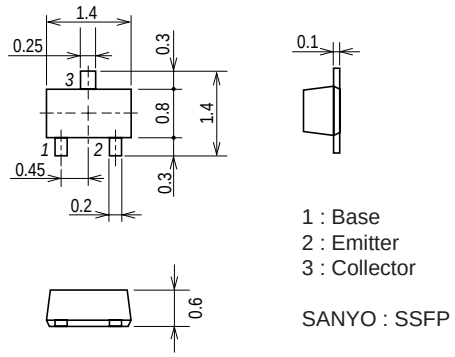
- Low noise : NF=2.6dB typ (f=2GHz).
- High cutoff frequency : $f_T$=9.0GHz typ ($V_{CE}$=1V).
  : $f_T$=11.5GHz typ ($V_{CE}$=3V).
- Low operating voltage.
- High gain : $|S21e|^2$=10.5dB typ (f=2GHz).
- Ultraminiature and thin flat lead package (1.4mm×0.8mm×0.6mm).

## Package Dimensions

unit : mm

2159

[2SC5648]




## Specifications

### Absolute Maximum Ratings at Ta=25°C

| Parameter | Symbol | Conditions | Ratings | Unit |
|---|---|---|---|---|
| Collector-to-Base Voltage | $V_{CBO}$ | | 9 | V |
| Collector-to-Emitter Voltage | $V_{CEO}$ | | 4 | V |
| Emitter-to-Base Voltage | $V_{EBO}$ | | 2 | V |
| Collector Current | $I_C$ | | 20 | mA |
| Collector Dissipation | $P_C$ | | 80 | mW |
| Junction Temperature | Tj | | 150 | °C |
| Storage Temperature | Tstg | | –55 to +150 | °C |

Marking : NH

Pay attention to handling since it is liable to be affected by static electricity due to the high-frequency process adopted.

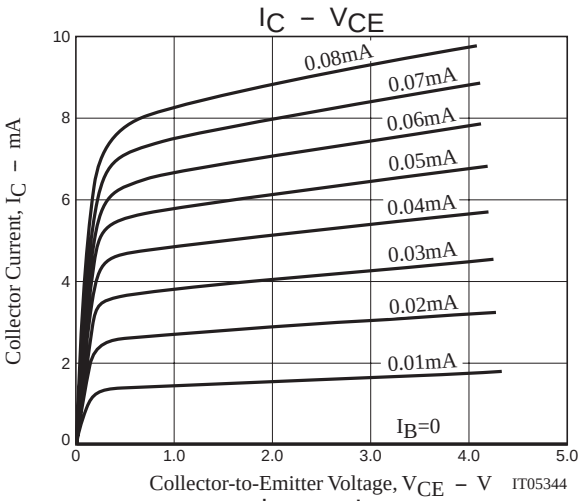


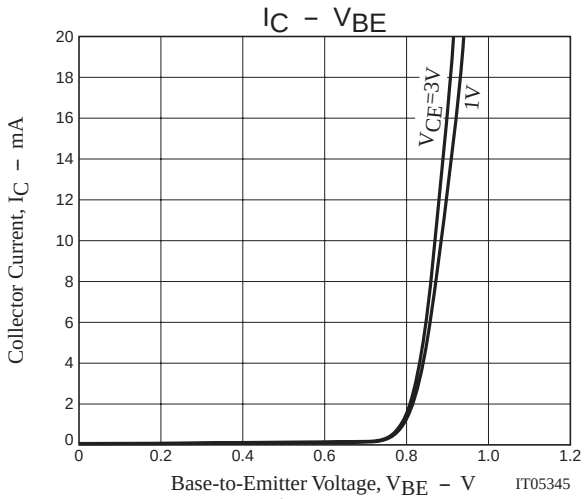

**SANYO Electric Co.,Ltd. Semiconductor Company**

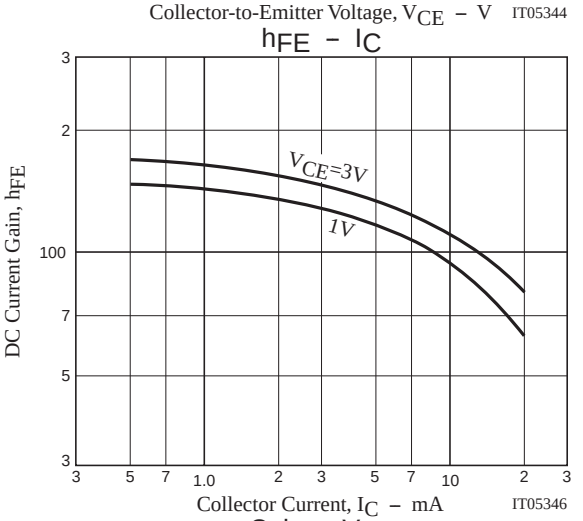
TOKYO OFFICE Tokyo Bldg., 1-10, 1 Chome, Ueno, Taito-ku, TOKYO, 110-8534 JAPAN

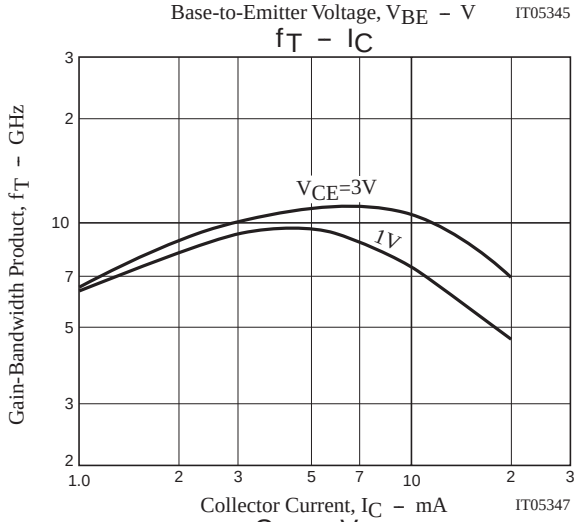
**Electrical Characteristics** at Ta=25°C

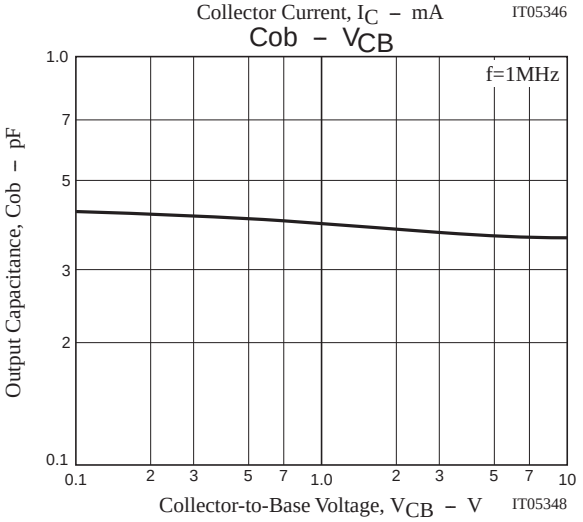
| Parameter | Symbol | Conditions | Ratings | | | Unit |
|---|---|---|---|---|---|---|
| | | | min | typ | max | |
| Collector Cutoff Current | $I_{CBO}$ | $V_{CB}$=5V, $I_E$=0 | | | 1.0 | μA |
| Emitter Cutoff Current | $I_{EBO}$ | $V_{EB}$=1V, $I_C$=0 | | | 10 | μA |
| DC Current Gain | $h_{FE}$ | $V_{CE}$=1V, $I_C$=5mA | 100 | | 160 | |
| Gain-Bandwidth Product | $f_T1$ | $V_{CE}$=1V, $I_C$=3mA | 7.0 | 9.0 | | GHz |
| | $f_T2$ | $V_{CE}$=3V, $I_C$=7mA | 9.5 | 11.5 | | GHz |
| Output Capacitance | Cob | $V_{CB}$=1V, f=1MHz | | 0.4 | 0.55 | pF |
| Reverse Transfer Capacitance | Cre | $V_{CB}$=1V, f=1MHz | | 0.3 | 0.45 | pF |
| Forward Transfer Gain | $\|S21e\|^2_1$ | $V_{CE}$=1V, $I_C$=3mA, f=2GHz | 7.5 | 9.0 | | dB |
| | $\|S21e\|^2_2$ | $V_{CE}$=3V, $I_C$=7mA, f=2GHz | 9.0 | 10.5 | | dB |
| Noise Figure | NF | $V_{CE}$=1V, $I_C$=3mA, f=2GHz | | 2.6 | 3.5 | dB |

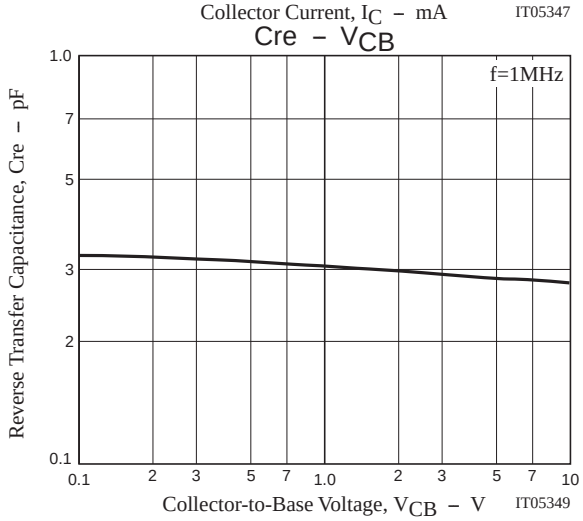


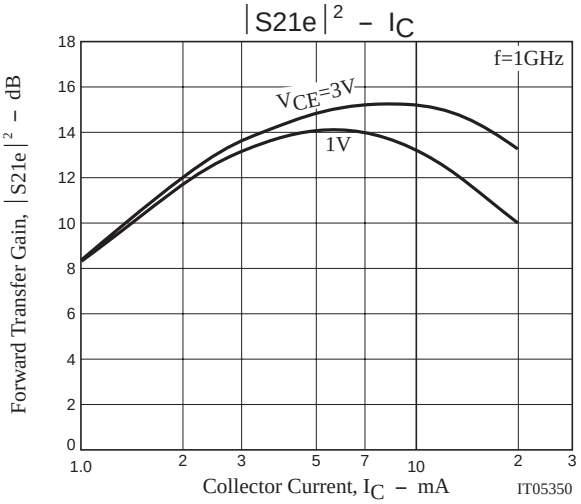



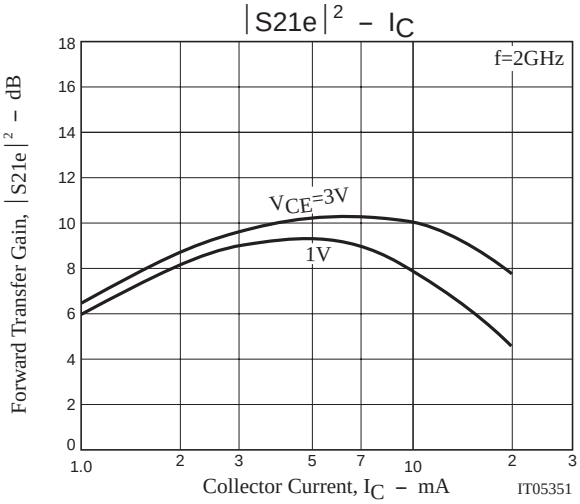



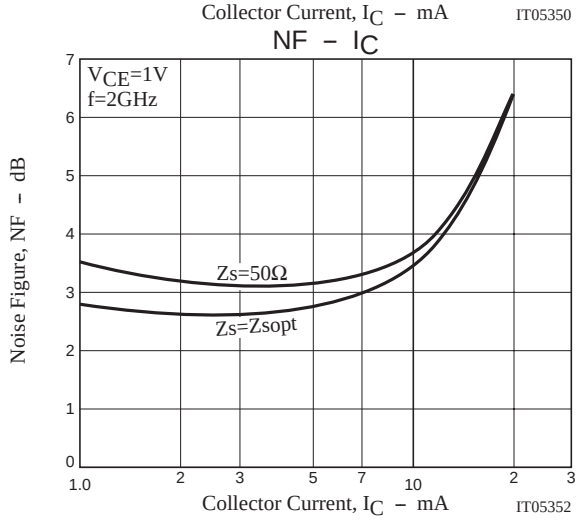



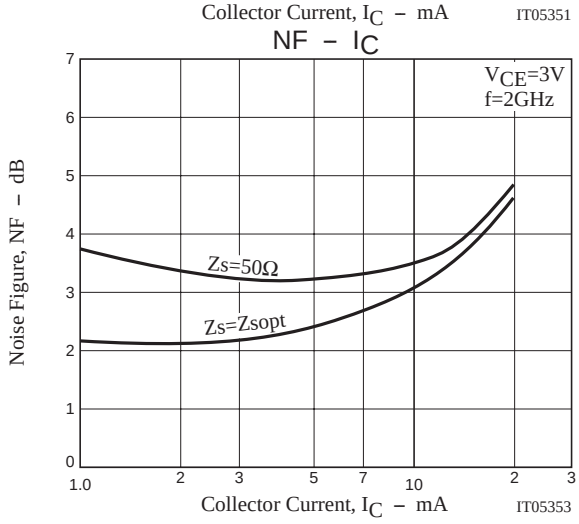



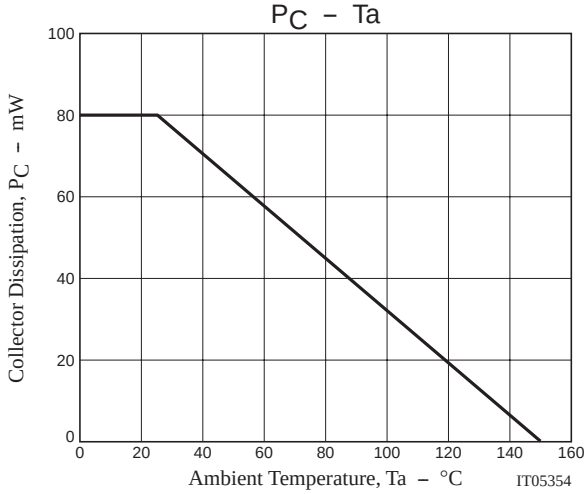




|S21e|² – IC
f=1GHz
VCE=3V
1V
Forward Transfer Gain, |S21e|² – dB
Collector Current, IC – mA
IT05350


|S21e|² – IC
f=2GHz
VCE=3V
1V
Forward Transfer Gain, |S21e|² – dB
Collector Current, IC – mA
IT05351


NF – IC
VCE=1V
f=2GHz
Zs=50Ω
Zs=Zsopt
Noise Figure, NF – dB
Collector Current, IC – mA
IT05352


NF – IC
VCE=3V
f=2GHz
Zs=50Ω
Zs=Zsopt
Noise Figure, NF – dB
Collector Current, IC – mA
IT05353


PC – Ta
Collector Dissipation, PC – mW
Ambient Temperature, Ta – °C
IT05354

## S Parameters (Common emitter)

$V_{CE}$=1V, $I_C$=1mA, $Z_O$=50Ω

| Freq(MHz) | $\|S_{11}\|$ | $\angle S_{11}$ | $\|S_{21}\|$ | $\angle S_{21}$ | $\|S_{12}\|$ | $\angle S_{12}$ | $\|S_{22}\|$ | $\angle S_{22}$ |
|---|---|---|---|---|---|---|---|---|
| 100 | 0.975 | –4.69 | 3.271 | 174.19 | 0.017 | 86.57 | 0.990 | –4.46 |
| 200 | 0.967 | –9.35 | 3.226 | 168.53 | 0.036 | 81.15 | 0.986 | –9.02 |
| 400 | 0.944 | –18.44 | 3.180 | 157.59 | 0.069 | 74.00 | 0.964 | –17.39 |
| 600 | 0.914 | –27.19 | 3.053 | 147.60 | 0.100 | 67.62 | 0.934 | –25.54 |
| 800 | 0.878 | –35.19 | 2.941 | 137.79 | 0.126 | 60.48 | 0.898 | –32.90 |
| 1000 | 0.840 | –42.88 | 2.837 | 128.85 | 0.150 | 55.64 | 0.866 | –39.53 |
| 1200 | 0.797 | –49.78 | 2.695 | 119.89 | 0.167 | 50.14 | 0.829 | –45.95 |
| 1400 | 0.749 | –56.22 | 2.538 | 111.34 | 0.181 | 46.03 | 0.797 | –51.01 |
| 1600 | 0.704 | –62.19 | 2.429 | 103.70 | 0.195 | 42.97 | 0.770 | –56.19 |
| 1800 | 0.656 | –67.22 | 2.313 | 96.49 | 0.208 | 40.30 | 0.748 | –60.45 |
| 2000 | 0.615 | –71.82 | 2.198 | 89.64 | 0.216 | 37.18 | 0.724 | –64.71 |
| 2200 | 0.572 | –75.76 | 2.087 | 82.66 | 0.227 | 34.50 | 0.704 | –68.61 |
| 2400 | 0.536 | –78.65 | 1.944 | 77.11 | 0.233 | 30.58 | 0.680 | –71.01 |
| 2600 | 0.505 | –81.98 | 1.883 | 72.19 | 0.237 | 29.99 | 0.669 | –74.54 |
| 2800 | 0.477 | –84.06 | 1.781 | 66.70 | 0.242 | 27.82 | 0.654 | –77.49 |
| 3000 | 0.453 | –88.40 | 1.736 | 62.72 | 0.247 | 27.65 | 0.644 | –80.39 |

$V_{CE}$=1V, $I_C$=3mA, $Z_O$=50Ω

| Freq(MHz) | $\|S_{11}\|$ | $\angle S_{11}$ | $\|S_{21}\|$ | $\angle S_{21}$ | $\|S_{12}\|$ | $\angle S_{12}$ | $\|S_{22}\|$ | $\angle S_{22}$ |
|---|---|---|---|---|---|---|---|---|
| 100 | 0.930 | –8.16 | 6.955 | 171.09 | 0.019 | 87.97 | 0.976 | –6.49 |
| 200 | 0.912 | –15.84 | 6.776 | 162.89 | 0.034 | 78.79 | 0.960 | –12.94 |
| 400 | 0.850 | –30.47 | 6.326 | 147.83 | 0.066 | 70.57 | 0.902 | –23.88 |
| 600 | 0.778 | –43.47 | 5.767 | 134.71 | 0.089 | 61.62 | 0.832 | –33.28 |
| 800 | 0.702 | –54.35 | 5.193 | 123.13 | 0.105 | 56.02 | 0.764 | –40.62 |
| 1000 | 0.636 | –63.64 | 4.705 | 113.55 | 0.121 | 52.20 | 0.710 | –46.69 |
| 1200 | 0.572 | –71.64 | 4.243 | 104.85 | 0.132 | 48.88 | 0.663 | –52.32 |
| 1400 | 0.516 | –78.53 | 3.810 | 97.18 | 0.142 | 46.93 | 0.627 | –55.91 |
| 1600 | 0.472 | –84.61 | 3.514 | 90.29 | 0.155 | 45.41 | 0.601 | –59.97 |
| 1800 | 0.427 | –89.72 | 3.229 | 84.10 | 0.164 | 44.67 | 0.582 | –63.36 |
| 2000 | 0.390 | –94.47 | 2.976 | 78.19 | 0.172 | 43.50 | 0.567 | –66.41 |
| 2200 | 0.356 | –98.24 | 2.776 | 72.34 | 0.183 | 42.81 | 0.551 | –69.72 |
| 2400 | 0.326 | –101.04 | 2.544 | 67.62 | 0.190 | 40.68 | 0.535 | –71.51 |
| 2600 | 0.299 | –104.46 | 2.424 | 63.69 | 0.198 | 40.64 | 0.532 | –74.24 |
| 2800 | 0.277 | –106.02 | 2.259 | 58.71 | 0.206 | 39.58 | 0.524 | –76.62 |
| 3000 | 0.262 | –110.57 | 2.171 | 55.54 | 0.216 | 40.40 | 0.521 | –79.45 |

$V_{CE}$=1V, $I_C$=5mA, $Z_O$=50Ω

| Freq(MHz) | $\|S_{11}\|$ | $\angle S_{11}$ | $\|S_{21}\|$ | $\angle S_{21}$ | $\|S_{12}\|$ | $\angle S_{12}$ | $\|S_{22}\|$ | $\angle S_{22}$ |
|---|---|---|---|---|---|---|---|---|
| 100 | 0.884 | –11.16 | 9.698 | 168.46 | 0.018 | 83.01 | 0.960 | –8.05 |
| 200 | 0.851 | –21.68 | 9.305 | 157.96 | 0.034 | 75.36 | 0.931 | –15.67 |
| 400 | 0.752 | –40.79 | 8.207 | 139.84 | 0.061 | 66.67 | 0.839 | –27.70 |
| 600 | 0.654 | –56.10 | 7.067 | 125.31 | 0.080 | 59.72 | 0.747 | –36.85 |
| 800 | 0.567 | –67.23 | 6.040 | 113.95 | 0.094 | 55.60 | 0.672 | –43.03 |
| 1000 | 0.502 | –77.42 | 5.290 | 104.74 | 0.107 | 52.31 | 0.619 | –47.70 |
| 1200 | 0.446 | –85.68 | 4.643 | 96.68 | 0.116 | 51.10 | 0.575 | –52.29 |
| 1400 | 0.400 | –92.90 | 4.109 | 89.46 | 0.128 | 50.47 | 0.549 | –55.27 |
| 1600 | 0.362 | –99.51 | 3.714 | 83.39 | 0.139 | 49.89 | 0.533 | –58.50 |
| 1800 | 0.329 | –104.08 | 3.385 | 77.69 | 0.148 | 49.35 | 0.518 | –61.26 |
| 2000 | 0.299 | –109.43 | 3.093 | 72.46 | 0.159 | 49.61 | 0.514 | –64.09 |
| 2200 | 0.271 | –114.23 | 2.873 | 67.22 | 0.171 | 48.46 | 0.502 | –67.17 |
| 2400 | 0.245 | –116.70 | 2.615 | 62.82 | 0.179 | 46.74 | 0.488 | –68.25 |
| 2600 | 0.225 | –121.18 | 2.489 | 59.17 | 0.188 | 46.98 | 0.493 | –71.74 |
| 2800 | 0.206 | –123.28 | 2.309 | 54.41 | 0.200 | 46.50 | 0.489 | –74.12 |
| 3000 | 0.198 | –128.83 | 2.208 | 51.43 | 0.210 | 46.23 | 0.489 | –76.70 |

$V_{CE}$=1V, $I_C$=10mA, $Z_O$=50Ω

| Freq(MHz) | $\|S_{11}\|$ | $\angle S_{11}$ | $\|S_{21}\|$ | $\angle S_{21}$ | $\|S_{12}\|$ | $\angle S_{12}$ | $\|S_{22}\|$ | $\angle S_{22}$ |
|---|---|---|---|---|---|---|---|---|
| 100 | 0.770 | –18.08 | 12.754 | 163.03 | 0.018 | 77.79 | 0.912 | –10.38 |
| 200 | 0.709 | –34.04 | 11.598 | 148.51 | 0.032 | 71.18 | 0.854 | –19.14 |
| 400 | 0.572 | –59.63 | 9.081 | 126.83 | 0.054 | 60.81 | 0.722 | –30.52 |
| 600 | 0.468 | –77.64 | 7.150 | 112.24 | 0.066 | 57.68 | 0.626 | –36.80 |
| 800 | 0.394 | –90.16 | 5.750 | 101.92 | 0.078 | 56.78 | 0.569 | –40.60 |
| 1000 | 0.353 | –101.06 | 4.863 | 93.51 | 0.090 | 56.14 | 0.536 | –43.68 |
| 1200 | 0.317 | –109.56 | 4.179 | 86.47 | 0.100 | 56.36 | 0.509 | –47.34 |
| 1400 | 0.289 | –117.32 | 3.633 | 80.28 | 0.111 | 56.41 | 0.498 | –49.64 |
| 1600 | 0.270 | –123.75 | 3.270 | 74.80 | 0.124 | 55.56 | 0.494 | –53.02 |
| 1800 | 0.249 | –128.92 | 2.948 | 69.59 | 0.135 | 55.52 | 0.492 | –55.55 |
| 2000 | 0.233 | –135.17 | 2.679 | 64.74 | 0.145 | 55.77 | 0.493 | –58.99 |
| 2200 | 0.216 | –140.62 | 2.476 | 59.73 | 0.158 | 53.86 | 0.487 | –62.22 |
| 2400 | 0.197 | –143.75 | 2.260 | 55.61 | 0.168 | 52.78 | 0.486 | –63.78 |
| 2600 | 0.188 | –149.14 | 2.141 | 52.22 | 0.180 | 52.41 | 0.493 | –67.24 |
| 2800 | 0.173 | –153.06 | 1.979 | 47.73 | 0.191 | 52.50 | 0.491 | –70.21 |
| 3000 | 0.173 | –157.72 | 1.894 | 44.90 | 0.203 | 52.48 | 0.497 | –73.38 |

$V_{CE}$=3V, $I_C$=1mA, $Z_O$=50Ω

| Freq(MHz) | $\|S_{11}\|$ | $\angle S_{11}$ | $\|S_{21}\|$ | $\angle S_{21}$ | $\|S_{12}\|$ | $\angle S_{12}$ | $\|S_{22}\|$ | $\angle S_{22}$ |
|---|---|---|---|---|---|---|---|---|
| 100 | 0.977 | –4.47 | 3.224 | 174.24 | 0.017 | 85.16 | 0.991 | –4.24 |
| 200 | 0.971 | –8.81 | 3.216 | 168.73 | 0.033 | 80.59 | 0.988 | –8.39 |
| 400 | 0.950 | –17.51 | 3.137 | 158.22 | 0.064 | 75.90 | 0.967 | –16.36 |
| 600 | 0.922 | –25.97 | 3.042 | 148.15 | 0.092 | 67.54 | 0.938 | –24.12 |
| 800 | 0.883 | –33.19 | 2.906 | 138.53 | 0.116 | 61.73 | 0.900 | –31.05 |
| 1000 | 0.850 | –40.49 | 2.821 | 129.85 | 0.138 | 55.94 | 0.871 | –37.23 |
| 1200 | 0.807 | –47.17 | 2.686 | 121.05 | 0.156 | 50.85 | 0.831 | –43.65 |
| 1400 | 0.763 | –53.33 | 2.550 | 112.56 | 0.169 | 46.87 | 0.797 | –48.27 |
| 1600 | 0.715 | –59.07 | 2.437 | 105.11 | 0.184 | 43.90 | 0.774 | –53.09 |
| 1800 | 0.670 | –63.45 | 2.329 | 97.86 | 0.194 | 41.20 | 0.747 | –57.32 |
| 2000 | 0.629 | –67.75 | 2.200 | 91.13 | 0.202 | 37.98 | 0.725 | –61.22 |
| 2200 | 0.585 | –71.43 | 2.097 | 84.11 | 0.215 | 34.96 | 0.698 | –65.16 |
| 2400 | 0.553 | –74.17 | 1.961 | 78.56 | 0.218 | 31.93 | 0.678 | –67.34 |
| 2600 | 0.517 | –77.41 | 1.902 | 73.61 | 0.223 | 30.66 | 0.663 | –70.71 |
| 2800 | 0.491 | –79.67 | 1.785 | 68.02 | 0.228 | 28.72 | 0.648 | –73.43 |
| 3000 | 0.469 | –82.84 | 1.752 | 64.13 | 0.233 | 28.98 | 0.637 | –76.17 |

$V_{CE}$=3V, $I_C$=3mA, $Z_O$=50Ω

| Freq(MHz) | $\|S_{11}\|$ | $\angle S_{11}$ | $\|S_{21}\|$ | $\angle S_{21}$ | $\|S_{12}\|$ | $\angle S_{12}$ | $\|S_{22}\|$ | $\angle S_{22}$ |
|---|---|---|---|---|---|---|---|---|
| 100 | 0.937 | –7.60 | 7.066 | 171.34 | 0.017 | 83.63 | 0.980 | –6.04 |
| 200 | 0.920 | –14.73 | 6.972 | 163.44 | 0.033 | 78.33 | 0.966 | –11.95 |
| 400 | 0.862 | –28.36 | 6.503 | 148.88 | 0.060 | 69.17 | 0.912 | –22.38 |
| 600 | 0.793 | –40.71 | 5.974 | 135.99 | 0.082 | 62.44 | 0.843 | –31.26 |
| 800 | 0.716 | –50.68 | 5.355 | 124.98 | 0.099 | 58.00 | 0.776 | –38.23 |
| 1000 | 0.652 | –59.69 | 4.887 | 115.54 | 0.115 | 53.64 | 0.727 | –44.03 |
| 1200 | 0.589 | –67.27 | 4.427 | 106.66 | 0.127 | 50.65 | 0.676 | –49.38 |
| 1400 | 0.532 | –73.84 | 4.000 | 98.75 | 0.134 | 48.50 | 0.640 | –52.99 |
| 1600 | 0.487 | –79.43 | 3.689 | 92.14 | 0.148 | 47.41 | 0.614 | –56.62 |
| 1800 | 0.440 | –84.11 | 3.394 | 85.80 | 0.156 | 46.22 | 0.592 | –59.61 |
| 2000 | 0.404 | –88.38 | 3.127 | 80.15 | 0.164 | 44.94 | 0.579 | –62.95 |
| 2200 | 0.366 | –91.86 | 2.920 | 74.35 | 0.176 | 43.44 | 0.560 | –65.94 |
| 2400 | 0.335 | –94.08 | 2.679 | 69.62 | 0.183 | 41.50 | 0.537 | –67.22 |
| 2600 | 0.308 | –96.66 | 2.555 | 65.72 | 0.191 | 42.23 | 0.535 | –69.99 |
| 2800 | 0.282 | –97.90 | 2.377 | 60.79 | 0.197 | 40.34 | 0.523 | –72.68 |
| 3000 | 0.271 | –102.11 | 2.285 | 57.61 | 0.209 | 40.82 | 0.518 | –74.78 |

$V_{CE}$=3V, $I_C$=5mA, $Z_O$=50Ω

| Freq(MHz) | $\|S_{11}\|$ | $\angle S_{11}$ | $\|S_{21}\|$ | $\angle S_{21}$ | $\|S_{12}\|$ | $\angle S_{12}$ | $\|S_{22}\|$ | $\angle S_{22}$ |
|---|---|---|---|---|---|---|---|---|
| 100 | 0.899 | –9.89 | 9.718 | 169.21 | 0.016 | 84.10 | 0.972 | –7.26 |
| 200 | 0.871 | –19.27 | 9.407 | 159.58 | 0.030 | 77.38 | 0.946 | –14.14 |
| 400 | 0.785 | –36.01 | 8.424 | 142.50 | 0.057 | 67.79 | 0.866 | –25.58 |
| 600 | 0.693 | –50.14 | 7.393 | 128.48 | 0.076 | 60.47 | 0.778 | –34.24 |
| 800 | 0.605 | –60.47 | 6.381 | 117.34 | 0.090 | 56.98 | 0.703 | –40.66 |
| 1000 | 0.541 | –70.18 | 5.640 | 108.16 | 0.103 | 53.96 | 0.650 | –45.44 |
| 1200 | 0.479 | –77.42 | 4.988 | 100.04 | 0.113 | 52.25 | 0.603 | –49.88 |
| 1400 | 0.429 | –83.93 | 4.431 | 92.72 | 0.122 | 51.54 | 0.573 | –52.73 |
| 1600 | 0.389 | –89.86 | 4.034 | 86.63 | 0.134 | 51.00 | 0.554 | –55.83 |
| 1800 | 0.353 | –94.17 | 3.681 | 80.89 | 0.144 | 49.87 | 0.536 | –58.62 |
| 2000 | 0.319 | –98.64 | 3.366 | 75.79 | 0.152 | 49.55 | 0.525 | –61.58 |
| 2200 | 0.288 | –102.61 | 3.120 | 70.25 | 0.165 | 48.50 | 0.513 | –64.33 |
| 2400 | 0.260 | –104.71 | 2.847 | 65.80 | 0.173 | 46.68 | 0.496 | –65.17 |
| 2600 | 0.239 | –108.27 | 2.710 | 62.33 | 0.184 | 46.41 | 0.497 | –68.10 |
| 2800 | 0.220 | –109.22 | 2.514 | 57.48 | 0.192 | 45.66 | 0.490 | –70.39 |
| 3000 | 0.209 | –114.12 | 2.403 | 54.56 | 0.200 | 46.18 | 0.491 | –72.83 |

$V_{CE}$=3V, $I_C$=10mA, $Z_O$=50Ω

| Freq(MHz) | $\|S_{11}\|$ | $\angle S_{11}$ | $\|S_{21}\|$ | $\angle S_{21}$ | $\|S_{12}\|$ | $\angle S_{12}$ | $\|S_{22}\|$ | $\angle S_{22}$ |
|---|---|---|---|---|---|---|---|---|
| 100 | 0.814 | –14.23 | 13.482 | 165.49 | 0.015 | 83.43 | 0.953 | –9.10 |
| 200 | 0.766 | –26.96 | 12.563 | 152.95 | 0.029 | 75.11 | 0.907 | –17.10 |
| 400 | 0.644 | –48.56 | 10.378 | 133.04 | 0.050 | 65.71 | 0.788 | –28.66 |
| 600 | 0.538 | –64.52 | 8.476 | 118.42 | 0.066 | 59.58 | 0.691 | –35.79 |
| 800 | 0.454 | –75.75 | 6.985 | 107.80 | 0.076 | 58.12 | 0.615 | –40.17 |
| 1000 | 0.403 | –85.44 | 5.983 | 99.38 | 0.088 | 57.19 | 0.574 | –43.73 |
| 1200 | 0.354 | –93.51 | 5.174 | 92.13 | 0.100 | 56.06 | 0.541 | –47.13 |
| 1400 | 0.319 | –100.31 | 4.529 | 85.63 | 0.110 | 56.11 | 0.521 | –49.27 |
| 1600 | 0.292 | –106.42 | 4.071 | 80.17 | 0.122 | 56.38 | 0.513 | –52.19 |
| 1800 | 0.266 | –111.30 | 3.693 | 75.00 | 0.131 | 55.83 | 0.501 | –54.69 |
| 2000 | 0.243 | –116.42 | 3.363 | 70.20 | 0.144 | 55.58 | 0.498 | –57.51 |
| 2200 | 0.222 | –121.23 | 3.109 | 65.08 | 0.155 | 54.24 | 0.490 | –60.49 |
| 2400 | 0.201 | –123.53 | 2.823 | 61.19 | 0.164 | 52.66 | 0.482 | –61.32 |
| 2600 | 0.185 | –128.70 | 2.684 | 57.79 | 0.175 | 52.72 | 0.488 | –64.37 |
| 2800 | 0.168 | –130.16 | 2.483 | 53.18 | 0.188 | 52.33 | 0.483 | –66.84 |
| 3000 | 0.165 | –135.42 | 2.374 | 50.48 | 0.198 | 51.81 | 0.486 | –69.60 |

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