

NPN SILICON RF TRANSISTOR NE661M04

NPN SILICON RF TRANSISTOR FOR LOW CURRENT, LOW NOISE, HIGH-GAIN AMPLIFICATION FLAT-LEAD 4-PIN THIN SUPER MINI-MOLD

FEATURES

- Low noise and high gain with low collector current
- $NF = 1.2 \text{ dB}$, $G_a = 16 \text{ dB TYP.}$ @ $f = 2 \text{ GHz}$, $V_{CE} = 2 \text{ V}$, $I_c = 2 \text{ mA}$
- Maximum stable power gain: $MSG = 22 \text{ dB TYP.}$ @ $f = 2 \text{ GHz}$, $V_{CE} = 2 \text{ V}$, $I_c = 5 \text{ mA}$
- $f_r = 25 \text{ GHz}$ technology
- Flat-lead 4-pin thin super mini-mold ($t = 0.59 \text{ mm}$)

ORDERING INFORMATION

| Part Number | Quantity | Packaging Style |
|-------------|------------------------------|---|
| NE661M04 | Loose product (50 pcs) | <ul style="list-style-type: none"> • 8 mm wide emboss taping • 1 pin (emitter), 2 pin (collector) feed hole direction |
| NE661M04-T2 | Taping product (3 kpcs/reel) | |

Remark To order evaluation samples, consult your NEC sales representative (available in 50-pcs units).

ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Ratings | Unit |
|------------------------------|------------------|-------------|------|
| Collector to Base Voltage | V_{CBO} | 15 | V |
| Collector to Emitter Voltage | V_{CEO} | 3.3 | V |
| Emitter to Base Voltage | V_{EBO} | 1.5 | V |
| Collector Current | I_c | 12 | mA |
| Total Power Dissipation | P_{tot}^{Note} | 39 | mW |
| Junction Temperature | T_j | 150 | °C |
| Storage Temperature | T_{stg} | -65 to +150 | °C |

Note $T_A = +25^\circ\text{C}$ (free air)

THERMAL RESISTANCE

| Item | Symbol | Value | Unit |
|--------------------------------|--------------|-------|------|
| Junction to Case Resistance | R_{th-j-c} | 240 | °C/W |
| Junction to Ambient Resistance | R_{th-j-a} | 650 | °C/W |

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_A = +25°C)

| Parameter | Symbol | Test Conditions | MIN. | TYP. | MAX. | Unit |
|---|-----------------------------------|--|------|------|------|------|
| DC characteristics | | | | | | |
| Collector Cut-off Current | I _{CBO} | V _{CB} = 5 V, I _E = 0 | – | – | 100 | nA |
| Emitter Cut-off Current | I _{EBO} | V _{EB} = 1 V, I _C = 0 | – | – | 100 | nA |
| DC Current Gain | h _{FE} ^{Note 1} | V _{CE} = 2 V, I _C = 5 mA | 50 | 70 | 100 | – |
| RF Characteristics | | | | | | |
| Reverse Transfer Capacitance | C _{re} ^{Note 2} | V _{CB} = 2 V, I _E = 0, f = 1 MHz | – | 0.08 | 0.12 | pF |
| Gain Bandwidth Product | f _T | V _{CE} = 3 V, I _C = 10 mA, f = 2 GHz | 20 | 25 | – | GHz |
| Noise Figure | NF | V _{CE} = 2 V, I _C = 2 mA, f = 2 GHz, Z _S = Z _{opt} | – | 1.2 | 1.5 | dB |
| Insertion Power Gain | S _{21e} ² | V _{CE} = 2 V, I _C = 5 mA, f = 2 GHz | 14 | 17 | – | dB |
| Maximum Stable Power Gain | MSG ^{Note 3} | V _{CE} = 2 V, I _C = 5 mA, f = 2 GHz | – | 22 | – | dB |
| Output Power at 1 dB Compression Point | P ₋₁ | V _{CE} = 2 V, I _C = 5 mA ^{Note 4} , f = 2 GHz | – | 5 | – | dBm |
| Output Power at Third Order Intercept Point | OIP ₃ | V _{CE} = 2 V, I _C = 5 mA ^{Note 4} , f = 2 GHz | – | 15 | – | – |

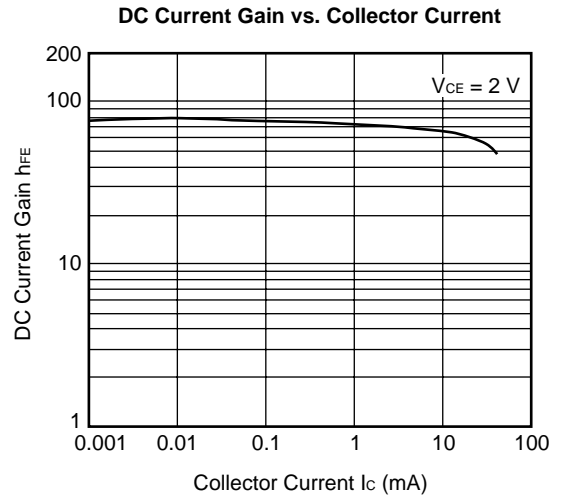
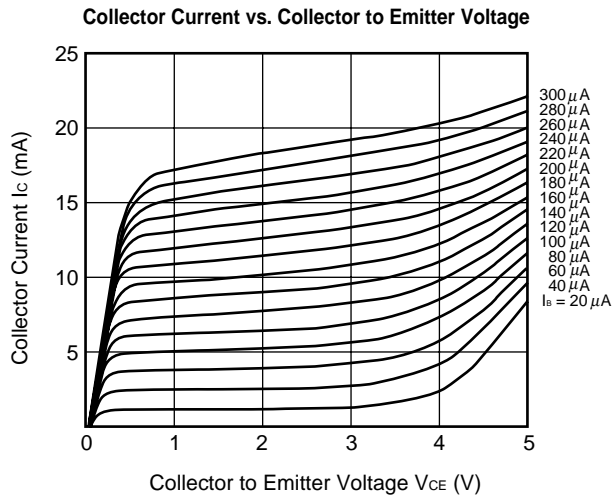
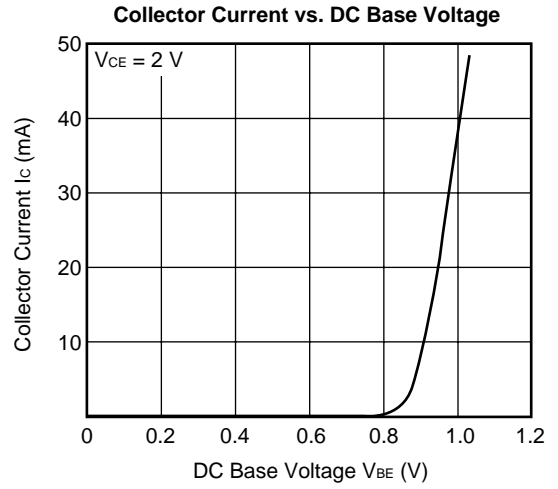
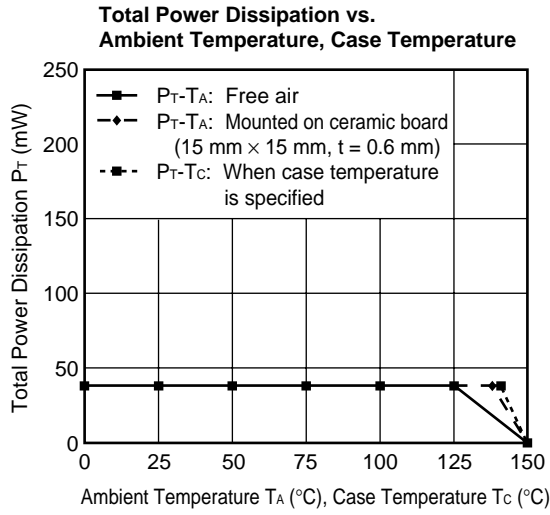
- Notes**
1. Pulse measurement PW ≤ 350 μs, Duty cycle ≤ 2%
 2. Emitter to base capacitance measured using capacitance meter (self-balancing bridge method) when the emitter is connected to the guard pin
 3. $MSG = \left| \frac{S_{21}}{S_{12}} \right|$
 4. Collector current when P₋₁ is output

h_{FE} CLASSIFICATION

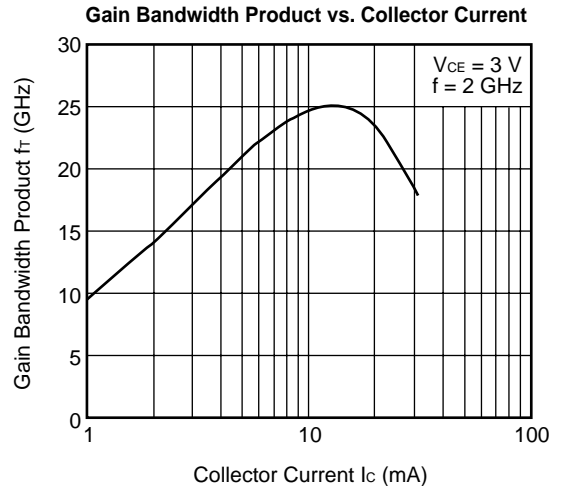
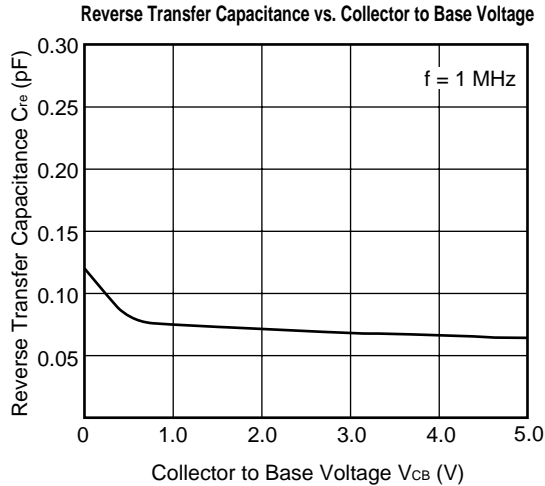
| | |
|-----------------|-----------|
| Rank | FB |
| Marking | T78 |
| h _{FE} | 50 to 100 |

TYPICAL CHARACTERISTICS (T_A = +25°C)

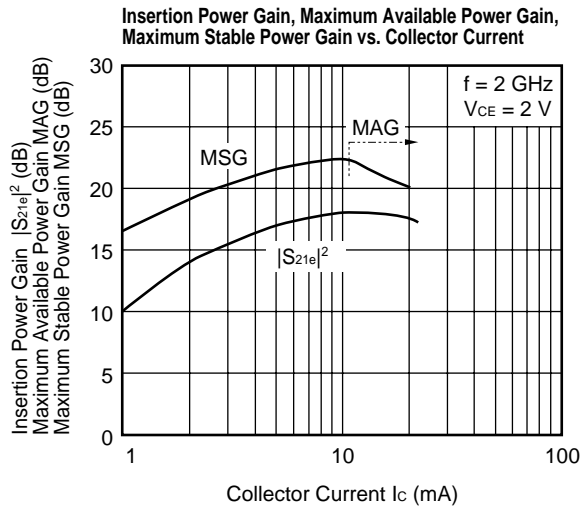
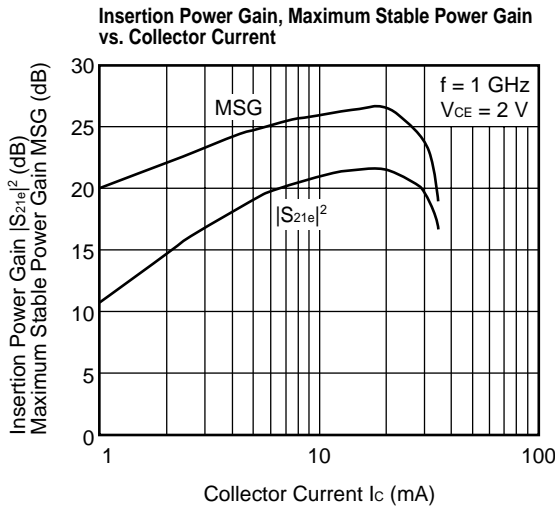
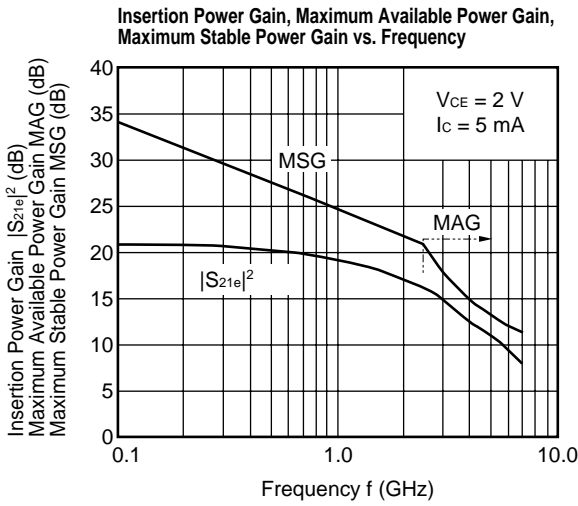
Thermal/DC Characteristics



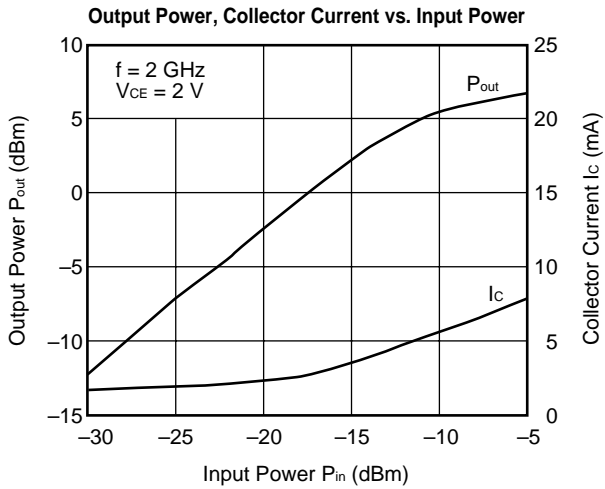
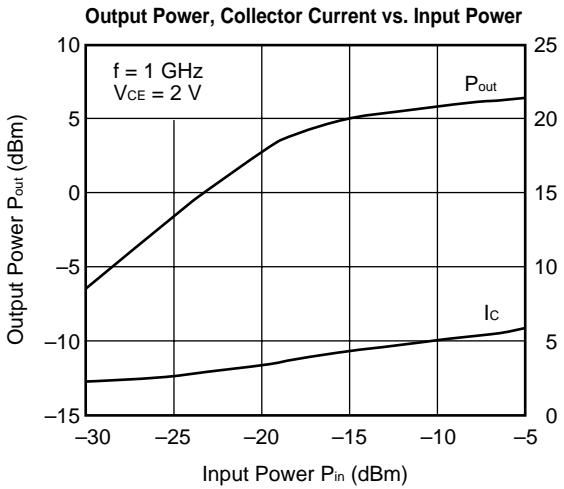
Capacitance/f_T Characteristics



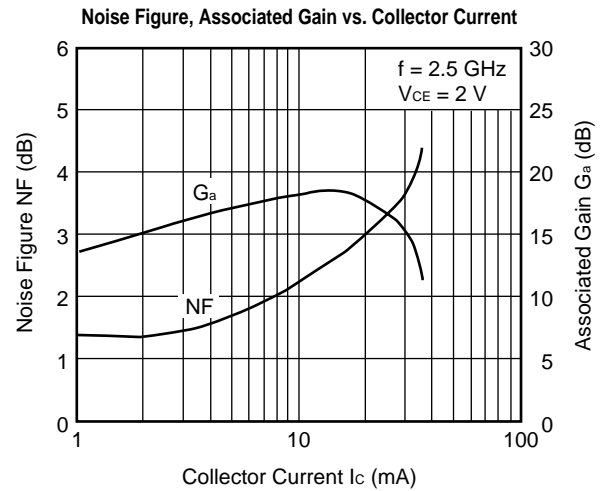
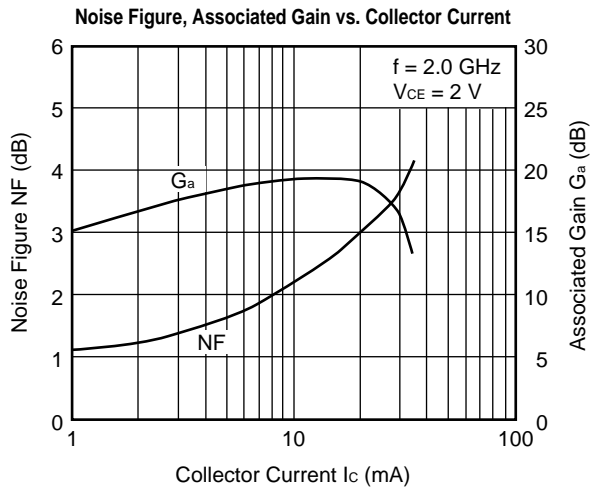
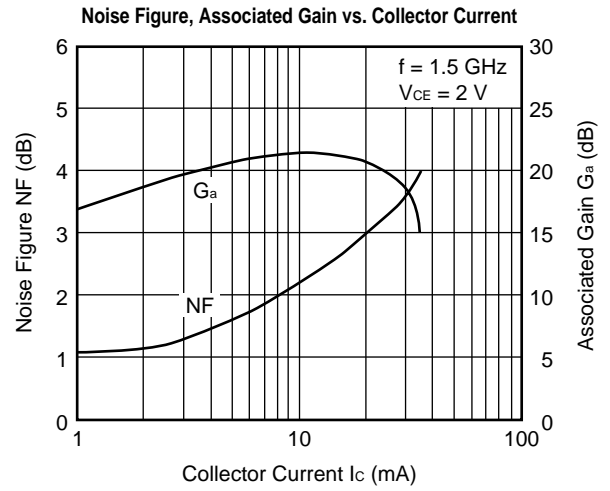
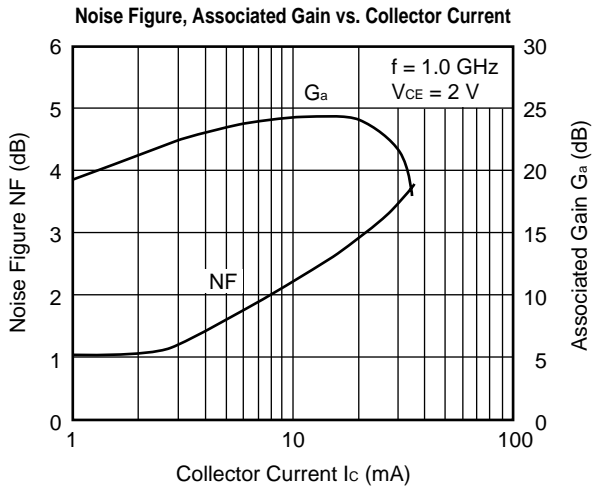
Gain Characteristics



Output Characteristics



Noise Characteristics



S PARAMETER

V_{CE} = 2 V, I_c = 2 mA

| Frequency GHz | S ₁₁ | | S ₂₁ | | S ₁₂ | | S ₂₂ | |
|------------------|-----------------|--------|-----------------|-------|-----------------|------|-----------------|--------|
| | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. |
| 0.1 | 0.90 | -3.7 | 6.45 | 174.8 | 0.00 | 81.9 | 0.98 | -3.6 |
| 0.2 | 0.89 | -7.1 | 6.25 | 170.8 | 0.01 | 77.9 | 0.95 | -6.0 |
| 0.3 | 0.89 | -10.6 | 6.12 | 167.2 | 0.01 | 75.5 | 0.94 | -7.9 |
| 0.4 | 0.88 | -14.2 | 6.02 | 163.6 | 0.02 | 75.7 | 0.92 | -9.5 |
| 0.5 | 0.87 | -17.6 | 5.96 | 160.2 | 0.02 | 74.1 | 0.91 | -11.0 |
| 0.6 | 0.87 | -21.0 | 5.87 | 156.9 | 0.02 | 72.4 | 0.90 | -12.7 |
| 0.7 | 0.86 | -24.6 | 5.79 | 153.4 | 0.03 | 70.0 | 0.89 | -14.3 |
| 0.8 | 0.84 | -28.0 | 5.69 | 150.3 | 0.03 | 68.7 | 0.88 | -15.6 |
| 0.9 | 0.83 | -31.5 | 5.64 | 147.1 | 0.03 | 66.9 | 0.87 | -17.3 |
| 1.0 | 0.82 | -35.0 | 5.54 | 143.8 | 0.03 | 65.2 | 0.86 | -18.9 |
| 1.1 | 0.80 | -38.6 | 5.50 | 140.7 | 0.04 | 63.3 | 0.84 | -20.3 |
| 1.2 | 0.79 | -42.0 | 5.42 | 137.7 | 0.04 | 62.2 | 0.83 | -21.8 |
| 1.3 | 0.77 | -45.8 | 5.37 | 134.5 | 0.04 | 60.1 | 0.82 | -23.3 |
| 1.4 | 0.76 | -49.4 | 5.28 | 131.6 | 0.04 | 58.4 | 0.81 | -24.9 |
| 1.5 | 0.74 | -53.4 | 5.25 | 128.5 | 0.05 | 57.0 | 0.80 | -26.4 |
| 1.6 | 0.72 | -57.1 | 5.19 | 125.2 | 0.05 | 55.0 | 0.78 | -27.8 |
| 1.7 | 0.70 | -61.0 | 5.14 | 122.4 | 0.05 | 53.1 | 0.77 | -29.3 |
| 1.8 | 0.68 | -65.0 | 5.06 | 119.2 | 0.05 | 52.1 | 0.76 | -30.7 |
| 1.9 | 0.66 | -69.2 | 5.04 | 116.1 | 0.06 | 50.9 | 0.75 | -32.2 |
| 2.0 | 0.64 | -73.3 | 4.98 | 113.0 | 0.06 | 49.1 | 0.73 | -33.6 |
| 2.1 | 0.62 | -77.7 | 4.91 | 109.9 | 0.06 | 46.6 | 0.72 | -35.1 |
| 2.2 | 0.60 | -82.1 | 4.82 | 106.9 | 0.06 | 45.6 | 0.71 | -36.3 |
| 2.3 | 0.58 | -86.9 | 4.78 | 103.6 | 0.06 | 43.8 | 0.69 | -37.8 |
| 2.4 | 0.56 | -91.8 | 4.68 | 100.6 | 0.06 | 42.2 | 0.68 | -39.2 |
| 2.5 | 0.55 | -97.1 | 4.62 | 97.5 | 0.07 | 40.5 | 0.66 | -40.5 |
| 2.6 | 0.52 | -102.5 | 4.53 | 94.1 | 0.07 | 39.0 | 0.65 | -41.9 |
| 2.7 | 0.50 | -108.7 | 4.46 | 90.8 | 0.07 | 37.0 | 0.63 | -43.0 |
| 2.8 | 0.47 | -115.5 | 4.29 | 87.5 | 0.07 | 34.8 | 0.62 | -44.1 |
| 2.9 | 0.42 | -120.2 | 4.11 | 85.2 | 0.06 | 34.7 | 0.61 | -44.0 |
| 3.0 | 0.40 | -119.0 | 4.06 | 84.6 | 0.06 | 38.1 | 0.61 | -45.4 |
| 4.0 | 0.47 | -159.3 | 3.24 | 66.5 | 0.07 | 33.4 | 0.51 | -55.3 |
| 5.0 | 0.49 | 163.9 | 2.74 | 45.5 | 0.07 | 33.5 | 0.44 | -69.8 |
| 6.0 | 0.56 | 141.2 | 2.34 | 26.7 | 0.08 | 35.9 | 0.40 | -88.9 |
| 7.0 | 0.63 | 123.9 | 2.00 | 9.3 | 0.09 | 37.0 | 0.38 | -112.9 |
| 8.0 | 0.69 | 111.6 | 1.70 | -6.5 | 0.11 | 35.9 | 0.39 | -138.6 |
| 9.0 | 0.74 | 102.1 | 1.44 | -21.4 | 0.12 | 31.3 | 0.44 | -163.4 |
| 10.0 | 0.79 | 95.1 | 1.19 | -34.9 | 0.13 | 25.3 | 0.52 | 175.7 |

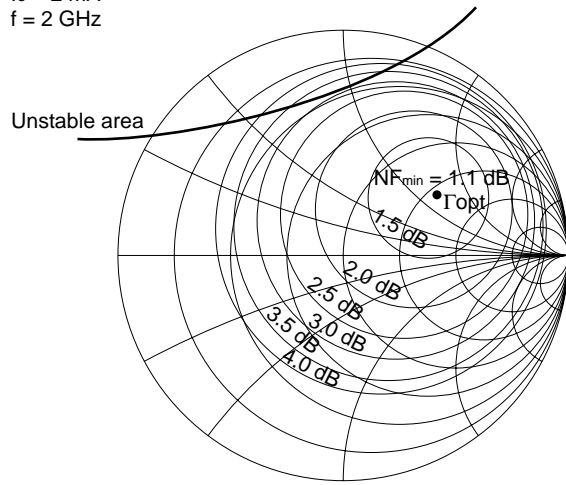
V_{CE} = 2 V, I_c = 5 mA

| Frequency GHz | S ₁₁ | | S ₂₁ | | S ₁₂ | | S ₂₂ | |
|------------------|-----------------|--------|-----------------|-------|-----------------|------|-----------------|--------|
| | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. | MAG. | ANG. |
| 0.1 | 0.82 | -4.7 | 10.44 | 173.8 | 0.00 | 80.8 | 0.97 | -4.1 |
| 0.2 | 0.82 | -9.2 | 10.28 | 168.8 | 0.01 | 75.3 | 0.94 | -7.1 |
| 0.3 | 0.80 | -13.8 | 10.09 | 164.2 | 0.01 | 75.0 | 0.92 | -9.4 |
| 0.4 | 0.79 | -18.0 | 9.89 | 159.8 | 0.01 | 74.1 | 0.90 | -11.5 |
| 0.5 | 0.78 | -22.4 | 9.73 | 155.6 | 0.02 | 72.2 | 0.88 | -13.4 |
| 0.6 | 0.76 | -26.6 | 9.55 | 151.5 | 0.02 | 70.4 | 0.87 | -15.4 |
| 0.7 | 0.74 | -31.1 | 9.36 | 147.4 | 0.02 | 68.0 | 0.85 | -17.3 |
| 0.8 | 0.72 | -35.3 | 9.19 | 143.5 | 0.03 | 66.6 | 0.84 | -18.9 |
| 0.9 | 0.70 | -39.4 | 9.01 | 139.6 | 0.03 | 64.9 | 0.82 | -20.8 |
| 1.0 | 0.68 | -43.6 | 8.82 | 135.8 | 0.03 | 63.3 | 0.80 | -22.4 |
| 1.1 | 0.66 | -47.9 | 8.67 | 132.0 | 0.03 | 61.2 | 0.78 | -23.9 |
| 1.2 | 0.63 | -51.9 | 8.46 | 128.6 | 0.04 | 60.7 | 0.77 | -25.5 |
| 1.3 | 0.61 | -56.2 | 8.27 | 124.8 | 0.04 | 58.7 | 0.75 | -26.9 |
| 1.4 | 0.58 | -60.3 | 8.07 | 121.5 | 0.04 | 57.8 | 0.73 | -28.4 |
| 1.5 | 0.56 | -64.7 | 7.91 | 117.9 | 0.04 | 56.3 | 0.72 | -29.7 |
| 1.6 | 0.53 | -68.9 | 7.72 | 114.5 | 0.04 | 55.5 | 0.70 | -31.0 |
| 1.7 | 0.51 | -73.3 | 7.54 | 111.3 | 0.05 | 53.8 | 0.69 | -32.3 |
| 1.8 | 0.49 | -77.6 | 7.35 | 108.2 | 0.05 | 53.4 | 0.67 | -33.6 |
| 1.9 | 0.46 | -82.0 | 7.18 | 105.0 | 0.05 | 51.9 | 0.65 | -34.9 |
| 2.0 | 0.44 | -86.7 | 7.00 | 102.0 | 0.05 | 51.6 | 0.64 | -36.1 |
| 2.1 | 0.42 | -91.6 | 6.83 | 98.9 | 0.05 | 49.6 | 0.62 | -37.2 |
| 2.2 | 0.40 | -96.5 | 6.66 | 95.9 | 0.05 | 49.6 | 0.61 | -38.2 |
| 2.3 | 0.38 | -101.9 | 6.49 | 92.9 | 0.05 | 48.3 | 0.60 | -39.5 |
| 2.4 | 0.36 | -107.6 | 6.32 | 90.0 | 0.05 | 47.4 | 0.58 | -40.5 |
| 2.5 | 0.35 | -113.6 | 6.16 | 87.0 | 0.06 | 46.2 | 0.57 | -41.7 |
| 2.6 | 0.33 | -120.2 | 6.00 | 84.1 | 0.06 | 45.3 | 0.55 | -42.7 |
| 2.7 | 0.32 | -127.9 | 5.82 | 80.9 | 0.06 | 44.6 | 0.53 | -43.4 |
| 2.8 | 0.30 | -137.3 | 5.59 | 77.9 | 0.06 | 42.5 | 0.52 | -43.8 |
| 2.9 | 0.25 | -144.7 | 5.29 | 76.3 | 0.06 | 44.1 | 0.52 | -43.2 |
| 3.0 | 0.23 | -142.4 | 5.22 | 76.0 | 0.06 | 48.2 | 0.52 | -44.8 |
| 4.0 | 0.31 | 175.3 | 4.23 | 62.3 | 0.06 | 46.8 | 0.44 | -48.3 |
| 5.0 | 0.42 | 147.1 | 3.50 | 41.8 | 0.08 | 45.6 | 0.36 | -70.4 |
| 6.0 | 0.51 | 130.2 | 2.94 | 25.6 | 0.09 | 42.7 | 0.31 | -89.6 |
| 7.0 | 0.58 | 116.8 | 2.52 | 9.8 | 0.10 | 38.6 | 0.29 | -115.3 |
| 8.0 | 0.65 | 106.9 | 2.16 | -5.0 | 0.12 | 34.4 | 0.31 | -143.0 |
| 9.0 | 0.71 | 99.0 | 1.85 | -19.3 | 0.13 | 28.7 | 0.36 | -168.2 |
| 10.0 | 0.76 | 92.8 | 1.57 | -32.6 | 0.14 | 22.9 | 0.44 | 172.1 |
| 11.0 | 0.78 | 89.2 | 1.36 | -44.5 | 0.14 | 17.8 | 0.53 | 158.5 |
| 12.0 | 0.79 | 84.8 | 1.16 | -55.1 | 0.15 | 13.4 | 0.60 | 149.8 |

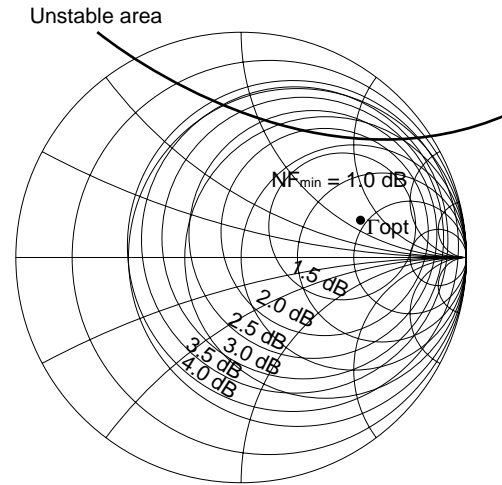
NOISE PARAMETER

<Equal NF circle>

$V_{CE} = 2\text{ V}$
 $I_C = 2\text{ mA}$
 $f = 2\text{ GHz}$



$V_{CE} = 2\text{ V}$
 $I_C = 2\text{ mA}$
 $f = 1\text{ GHz}$



$V_{CE} = 2\text{ V}, I_C = 2\text{ mA}$

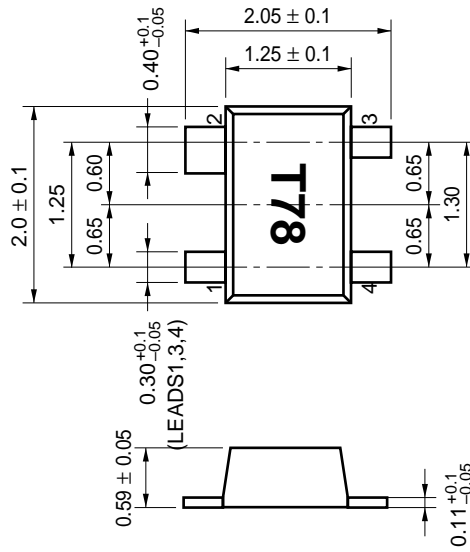
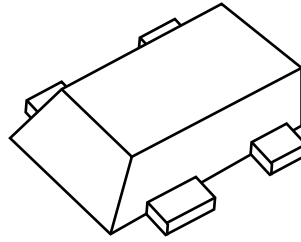
| f (GHz) | NF _{min} (dB) | G _a (dB) | Γ _{opt} | | R _n /50 |
|------------|---------------------------|------------------------|------------------|------|--------------------|
| | | | MAG. | ANG. | |
| 0.8 | 0.93 | 22.9 | 0.54 | 13.3 | 0.47 |
| 0.9 | 0.95 | 22.2 | 0.54 | 14.9 | 0.47 |
| 1.0 | 0.97 | 21.6 | 0.54 | 16.4 | 0.47 |
| 1.5 | 1.08 | 18.8 | 0.53 | 24.6 | 0.45 |
| 1.8 | 1.14 | 17.5 | 0.51 | 30.3 | 0.43 |
| 1.9 | 1.16 | 17.1 | 0.50 | 32.4 | 0.42 |
| 2.0 | 1.18 | 16.7 | 0.49 | 34.6 | 0.41 |
| 2.5 | 1.29 | 15.2 | 0.44 | 47.7 | 0.35 |

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

| f (GHz) | NF _{min} (dB) | G _a (dB) | Γ _{opt} | | R _n /50 |
|------------|---------------------------|------------------------|------------------|------|--------------------|
| | | | MAG. | ANG. | |
| 0.8 | 1.59 | 24.7 | 0.38 | 10.7 | 0.43 |
| 0.9 | 1.60 | 24.1 | 0.38 | 11.9 | 0.43 |
| 1.0 | 1.60 | 23.4 | 0.38 | 13.2 | 0.43 |
| 1.5 | 1.62 | 20.7 | 0.36 | 20.5 | 0.41 |
| 1.8 | 1.63 | 19.3 | 0.34 | 25.7 | 0.38 |
| 1.9 | 1.63 | 18.9 | 0.33 | 27.5 | 0.38 |
| 2.0 | 1.63 | 18.5 | 0.32 | 29.4 | 0.37 |
| 2.5 | 1.65 | 16.9 | 0.26 | 40.1 | 0.32 |

PACKAGE DRAWINGS

Flat-lead 4-pin thin super mini-mold (unit: mm)



Pin connections

- 1. Emitter
- 2. Collector
- 3. Emitter
- 4. Base

SOLDERING CONDITIONS

Solder this product under the following recommended conditions.

For soldering methods and conditions other than those recommended, consult NEC.

| Soldering Method(s) | Soldering Conditions | Recommended Conditions Symbol |
|---------------------|---|-------------------------------|
| Infrared reflow | Package peak temperature: 235°C, Time: 30 sec max. (210°C min.), Number of times: twice max., Maximum number of days: None ^{Note} | IR35-00-2 |
| VPS | Package peak temperature: 215°C, Time: 40 sec max. (200°C min.), Number of times: twice max., Maximum number of days: None ^{Note} | VP15-00-2 |
| Wave soldering | Solder bath temperature: 260°C, Time: 10 sec max., Number of times: once, Maximum number of days: None ^{Note} | WS60-00-1 |

Note Number of days in storage after the dry pack has been opened. The storage conditions are at 25°C, 65% RH MAX.

Caution Do not use two or more soldering methods in combination.

For details of the recommended soldering conditions, refer to information document **Semiconductor Device Mounting Technology Manual (C10535E)**.

[MEMO]

- **The information in this document is current as of June, 2000. The information is subject to change without notice. For actual design-in, refer to the latest publications of NEC's data sheets or data books, etc., for the most up-to-date specifications of NEC semiconductor products. Not all products and/or types are available in every country. Please check with an NEC sales representative for availability and additional information.**
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 - "Standard": Computers, office equipment, communications equipment, test and measurement equipment, audio and visual equipment, home electronic appliances, machine tools, personal electronic equipment and industrial robots
 - "Special": Transportation equipment (automobiles, trains, ships, etc.), traffic control systems, anti-disaster systems, anti-crime systems, safety equipment and medical equipment (not specifically designed for life support)
 - "Specific": Aircraft, aerospace equipment, submersible repeaters, nuclear reactor control systems, life support systems and medical equipment for life support, etc.
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 - (2) "NEC semiconductor products" means any semiconductor product developed or manufactured by or for NEC (as defined above).