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# BFR740L3RH

Low Noise Silicon Germanium Bipolar RF Transistor

## Data Sheet

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**Revision History: 2012-06-21, Version 2**

| Page | Subjects (major changes since last revision)   |
|------|--|
|      | This data sheet replaces the revision from 2010-09-08. The production processes have not been changed and the device properties remain the same. Only the product description has been expanded and the characteristic curves taken with another test setup. |
|      |  |
|      |  |
|      |  |

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Last Trademarks Update 2011-11-11

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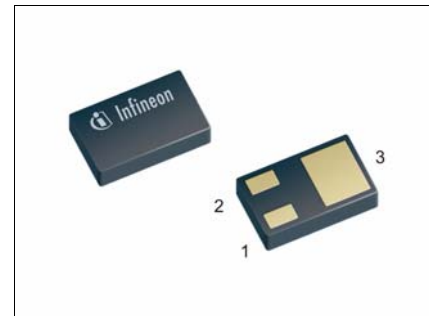
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## 1 Product Brief

The BFR740L3RH is a very low noise wideband NPN RF transistor. The device is based on Infineon's reliable high volume silicon germanium carbon (SiGe:C) heterojunction bipolar technology. The BFR740L3RH provides a transition frequency  $f_T$  of 42 GHz and is suited for low voltage applications ( $V_{CEO,max} = 4 V$ ) from VHF to 12 GHz. Due to its low power consumption the device is very energy efficient and well suited for mobile applications. The BFR740L3RH is housed in a very thin small leadless package ideal for modules.

## 2 Features

- Very low noise figure  $NF_{min} = 0.5$  dB at 1.9 GHz, 0.8 dB at 5.5 GHz, 3 V, 6 mA
- High power gain  $G_{ms} = 20$  dB at 5.5 GHz, 15 mA, 3 V
- Very thin small leadless package (height only 0.31 mm), hence ideal for modules with compact size and low profile height
- Pb-free (RoHS compliant) and halogen-free package
- Qualification report according to AEC-Q101 available



TSLP-3-9



## 3 Applications

As Low Noise Amplifier (LNA) in

- Mobile, portable and fixed connectivity applications: WLAN 802.11a/b/g/n, WiMAX 2.5/3.5/5.5 GHz, UWB, Bluetooth
- Satellite communication systems: Navigation systems (GPS, Glonass), satellite radio (SDARs, DAB) and C-band LNB
- Multimedia applications such as mobile/portable TV, CATV, FM Radio
- 3G/4G UMTS/LTE mobile phone applications
- ISM applications like RKE, AMR and Zigbee, as well as for emerging wireless applications

As discrete active mixer, amplifier in VCOs and buffer amplifier

**Attention: ESD (Electrostatic discharge) sensitive device, observe handling precautions**



## 4 Pin Configuration

| Product Name | Package  | Pin Configuration <sup>1)</sup> |       |       | Marking |
|--------------|----------|---------------------------------|-------|-------|---------|
| BFR740L3RH   | TSLP-3-9 | 1 = B                           | 2 = C | 3 = E | R9      |

1) See [“Package Information TSLP-3-9” on Page 28](#)

## 5 Maximum Ratings

**Table 5-1 Maximum Ratings at  $T_A = 25\text{ °C}$  (unless otherwise specified)**

| Parameter                             | Symbol    | Values |            | Unit | Note / Test Condition                                      |
|---------------------------------------|-----------|--------|------------|------|--|
|                                       |           | Min.   | Max.       |      |  |
| Collector emitter voltage             | $V_{CEO}$ | –<br>– | 4.0<br>3.5 | V    | Open base<br>$T_A = 25\text{ °C}$<br>$T_A = -55\text{ °C}$ |
| Collector emitter voltage             | $V_{CES}$ | –      | 13         | V    | E-B short circuited  |
| Collector base voltage                | $V_{CBO}$ | –      | 13         | V    | Open emitter   |
| Emitter base voltage                  | $V_{EBO}$ | –      | 1.2        | V    | Open collector   |
| Collector current                     | $I_C$     | –      | 40         | mA   | –  |
| Base current                          | $I_B$     | –      | 4          | mA   | –  |
| Total power dissipation <sup>1)</sup> | $P_{tot}$ | –      | 160        | mW   | $T_S \leq 105\text{ °C}$                                   |
| Junction temperature                  | $T_J$     | –      | 150        | °C   | –  |
| Storage temperature                   | $T_{Stg}$ | -55    | 150        | °C   | –  |

1)  $T_S$  is the soldering point temperature.  $T_S$  is measured on the emitter lead at the soldering point of the pcb.

**Attention: Stresses above the max. values listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Maximum ratings are absolute ratings; exceeding only one of these values may cause irreversible damage to the integrated circuit.**

## 6 Thermal Characteristics

Table 6-1 Thermal Resistance

| Parameter                                | Symbol     | Values |      |      | Unit | Note / Test Condition |
|--|------------|--------|------|------|------|-----------------------|
|  |            | Min.   | Typ. | Max. |      |                       |
| Junction - soldering point <sup>1)</sup> | $R_{thJS}$ | –      | 280  | –    | K/W  | –                     |

1) For the definition of  $R_{thJS}$  please refer to Application Note AN077 (Thermal Resistance Calculation)

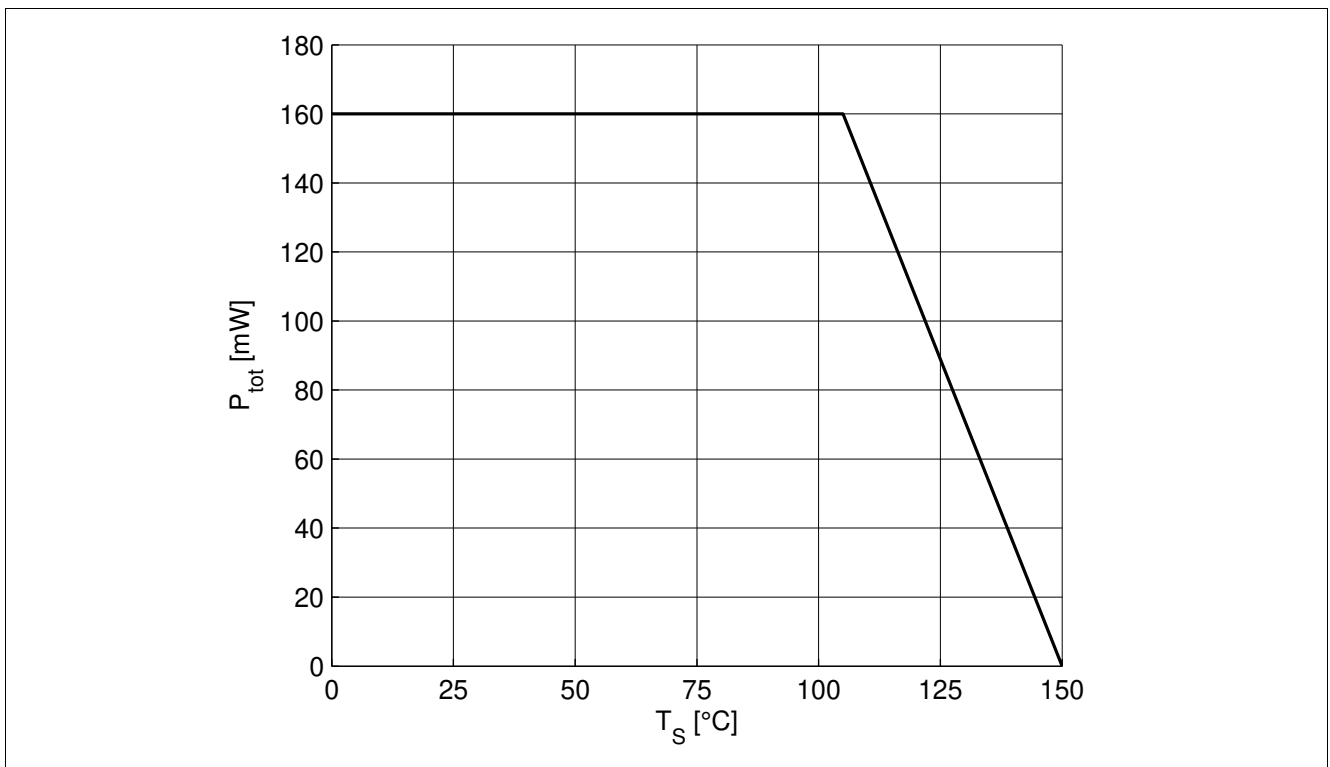


Figure 6-1 Total Power Dissipation  $P_{tot} = f(T_s)$

## 7 Electrical Characteristics

### 7.1 DC Characteristics

**Table 7-1 DC Characteristics at  $T_A = 25\text{ °C}$** 

| Parameter                           | Symbol        | Values |        |           | Unit | Note / Test Condition  |
|-------------------------------------|---------------|--------|--------|-----------|------|--|
|                                     |               | Min.   | Typ.   | Max.      |      |  |
| Collector emitter breakdown voltage | $V_{(BR)CEO}$ | 4      | 4.7    | –         | V    | $I_C = 1\text{ mA}$ , $I_B = 0$<br>Open base   |
| Collector emitter leakage current   | $I_{CES}$     | –      | 1<br>1 | 400<br>40 | nA   | $V_{CE} = 13\text{ V}$ , $V_{BE} = 0$<br>$V_{CE} = 5\text{ V}$ , $V_{BE} = 0$<br>E-B short circuited |
| Collector base leakage current      | $I_{CBO}$     | –      | 1      | 40        | nA   | $V_{CB} = 5\text{ V}$ , $I_E = 0$<br>Open emitter  |
| Emitter base leakage current        | $I_{EBO}$     | –      | 1      | 40        | nA   | $V_{EB} = 0.5\text{ V}$ , $I_C = 0$<br>Open collector  |
| DC current gain                     | $h_{FE}$      | 160    | 250    | 400       |      | $V_{CE} = 3\text{ V}$ , $I_C = 25\text{ mA}$<br>Pulse measured                                       |

### 7.2 General AC Characteristics

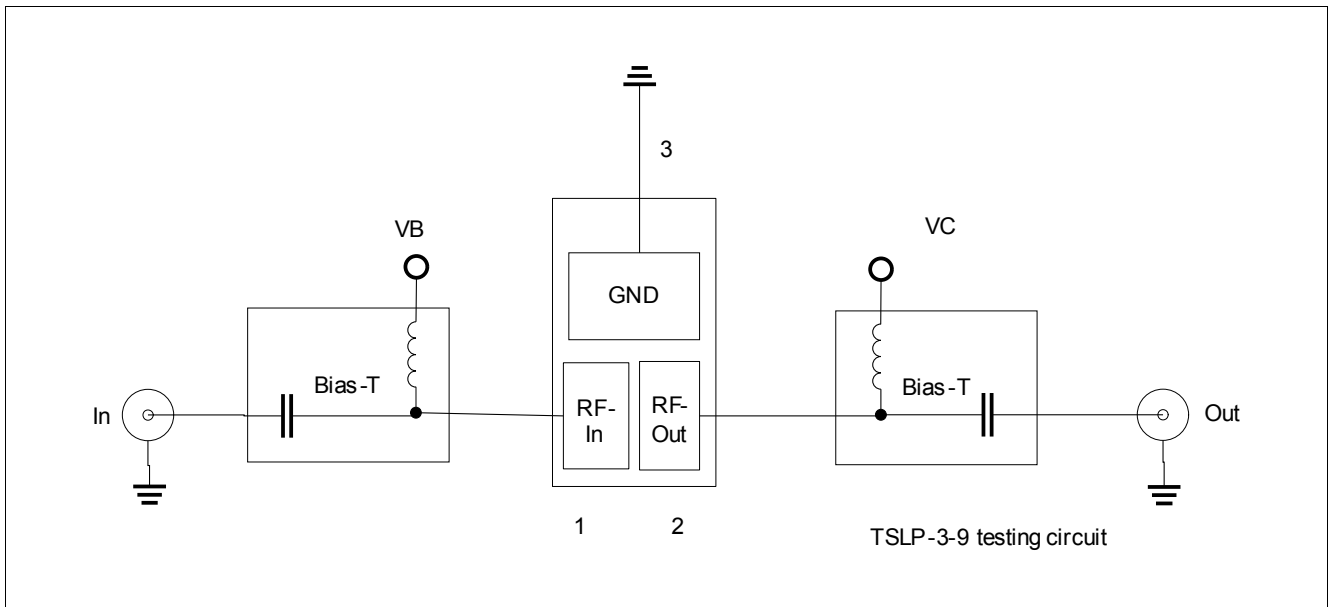
**Table 7-2 General AC Characteristics at  $T_A = 25\text{ °C}$** 

| Parameter                     | Symbol   | Values |      |      | Unit | Note / Test Condition  |
|-------------------------------|----------|--------|------|------|------|--|
|                               |          | Min.   | Typ. | Max. |      |  |
| Transition frequency          | $f_T$    | –      | 47   | –    | GHz  | $V_{CE} = 3\text{ V}$ , $I_C = 25\text{ mA}$<br>$f = 2\text{ GHz}$                 |
| Collector base capacitance    | $C_{CB}$ | –      | 0.09 | 0.12 | pF   | $V_{CB} = 3\text{ V}$ , $V_{BE} = 0$<br>$f = 1\text{ MHz}$<br>Emitter grounded     |
| Collector emitter capacitance | $C_{CE}$ | –      | 0.3  | –    | pF   | $V_{CE} = 3\text{ V}$ , $V_{BE} = 0$<br>$f = 1\text{ MHz}$<br>Base grounded        |
| Emitter base capacitance      | $C_{EB}$ | –      | 0.4  | –    | pF   | $V_{EB} = 0.5\text{ V}$ , $V_{CB} = 0$<br>$f = 1\text{ MHz}$<br>Collector grounded |



### 7.3 Frequency Dependent AC Characteristics

Measurement setup is a test fixture with Bias-T's in a 50 Ω system,  $T_A = 25\text{ °C}$



**Figure 7-1 BFR740L3RH Testing Circuit**

**Table 7-3 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 150\text{ MHz}$**

| Parameter                           | Symbol       | Values |      |      | Unit | Note / Test Condition          |
|-------------------------------------|--------------|--------|------|------|------|--------------------------------|
|                                     |              | Min.   | Typ. | Max. |      |                                |
| <b>Power Gain</b>                   |              |        |      |      | dB   |                                |
| Maximum power gain                  | $G_{ms}$     | –      | 35   | –    |      | $I_C = 15\text{ mA}$           |
| Transducer gain                     | $ S_{21} ^2$ | –      | 29.5 | –    |      | $I_C = 15\text{ mA}$           |
| <b>Minimum Noise Figure</b>         |              |        |      |      | dB   |                                |
| Minimum noise figure                | $NF_{min}$   | –      | 0.45 | –    |      | $I_C = 6\text{ mA}$            |
| Associated gain                     | $G_{ass}$    | –      | 27.5 | –    |      | $I_C = 6\text{ mA}$            |
| <b>Linearity</b>                    |              |        |      |      | dBm  | $Z_S = Z_L = 50\text{ }\Omega$ |
| 1 dB compression point at output    | $OP_{1dB}$   | –      | 3.5  | –    |      | $I_C = 15\text{ mA}$           |
| 3rd order intercept point at output | $OIP_3$      | –      | 21   | –    |      | $I_C = 15\text{ mA}$           |

**Table 7-4 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 0.45\text{ GHz}$**

| Parameter          | Symbol       | Values |      |      | Unit | Note / Test Condition |
|--------------------|--------------|--------|------|------|------|-----------------------|
|                    |              | Min.   | Typ. | Max. |      |                       |
| <b>Power Gain</b>  |              |        |      |      | dB   |                       |
| Maximum power gain | $G_{ms}$     | –      | 31   | –    |      | $I_C = 15\text{ mA}$  |
| Transducer gain    | $ S_{21} ^2$ | –      | 29   | –    |      | $I_C = 15\text{ mA}$  |

**Electrical Characteristics**
**Table 7-4 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 0.45\text{ GHz}$  (cont'd)**

| Parameter                           | Symbol            | Values |      |      | Unit | Note / Test Condition    |
|-------------------------------------|-------------------|--------|------|------|------|--------------------------|
|                                     |                   | Min.   | Typ. | Max. |      |                          |
| <b>Minimum Noise Figure</b>         |                   |        |      |      |      |                          |
| Minimum noise figure                | $NF_{\min}$       | –      | 0.45 | –    | dB   | $I_C = 6\text{ mA}$      |
| Associated gain                     | $G_{\text{ass}}$  | –      | 26.5 | –    |      | $I_C = 6\text{ mA}$      |
| <b>Linearity</b>                    |                   |        |      |      |      |                          |
| 1 dB compression point at output    | $OP_{1\text{dB}}$ | –      | 7    | –    | dBm  | $Z_S = Z_L = 50\ \Omega$ |
| 3rd order intercept point at output | $OIP_3$           | –      | 21   | –    |      | $I_C = 15\text{ mA}$     |

## Electrical Characteristics

 Table 7-5 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 0.9\text{ GHz}$ 

| Parameter                           | Symbol       | Values |      |      | Unit | Note / Test Condition    |
|-------------------------------------|--------------|--------|------|------|------|--------------------------|
|                                     |              | Min.   | Typ. | Max. |      |                          |
| <b>Power Gain</b>                   |              |        |      |      |      |                          |
| Maximum power gain                  | $G_{ms}$     | –      | 28   | –    | dB   | $I_C = 15\text{ mA}$     |
| Transducer gain                     | $ S_{21} ^2$ | –      | 27   | –    |      | $I_C = 15\text{ mA}$     |
| <b>Minimum Noise Figure</b>         |              |        |      |      |      |                          |
| Minimum noise figure                | $NF_{min}$   | –      | 0.45 | –    | dB   | $I_C = 6\text{ mA}$      |
| Associated gain                     | $G_{ass}$    | –      | 25   | –    |      | $I_C = 6\text{ mA}$      |
| <b>Linearity</b>                    |              |        |      |      |      |                          |
| 1 dB compression point at output    | $OP_{1dB}$   | –      | 8    | –    | dBm  | $Z_S = Z_L = 50\ \Omega$ |
| 3rd order intercept point at output | $OIP_3$      | –      | 22.5 | –    |      | $I_C = 15\text{ mA}$     |

 Table 7-6 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 1.5\text{ GHz}$ 

| Parameter                           | Symbol       | Values |      |      | Unit | Note / Test Condition    |
|-------------------------------------|--------------|--------|------|------|------|--------------------------|
|                                     |              | Min.   | Typ. | Max. |      |                          |
| <b>Power Gain</b>                   |              |        |      |      |      |                          |
| Maximum power gain                  | $G_{ms}$     | –      | 25.5 | –    | dB   | $I_C = 15\text{ mA}$     |
| Transducer gain                     | $ S_{21} ^2$ | –      | 25   | –    |      | $I_C = 15\text{ mA}$     |
| <b>Minimum Noise Figure</b>         |              |        |      |      |      |                          |
| Minimum noise figure                | $NF_{min}$   | –      | 0.5  | –    | dB   | $I_C = 6\text{ mA}$      |
| Associated gain                     | $G_{ass}$    | –      | 22.5 | –    |      | $I_C = 6\text{ mA}$      |
| <b>Linearity</b>                    |              |        |      |      |      |                          |
| 1 dB compression point at output    | $OP_{1dB}$   | –      | 8    | –    | dBm  | $Z_S = Z_L = 50\ \Omega$ |
| 3rd order intercept point at output | $OIP_3$      | –      | 23   | –    |      | $I_C = 15\text{ mA}$     |

 Table 7-7 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 1.9\text{ GHz}$ 

| Parameter                           | Symbol       | Values |      |      | Unit | Note / Test Condition    |
|-------------------------------------|--------------|--------|------|------|------|--------------------------|
|                                     |              | Min.   | Typ. | Max. |      |                          |
| <b>Power Gain</b>                   |              |        |      |      |      |                          |
| Maximum power gain                  | $G_{ms}$     | –      | 24.5 | –    | dB   | $I_C = 15\text{ mA}$     |
| Transducer gain                     | $ S_{21} ^2$ | –      | 23.5 | –    |      | $I_C = 15\text{ mA}$     |
| <b>Minimum Noise Figure</b>         |              |        |      |      |      |                          |
| Minimum noise figure                | $NF_{min}$   | –      | 0.5  | –    | dB   | $I_C = 6\text{ mA}$      |
| Associated gain                     | $G_{ass}$    | –      | 21   | –    |      | $I_C = 6\text{ mA}$      |
| <b>Linearity</b>                    |              |        |      |      |      |                          |
| 1 dB compression point at output    | $OP_{1dB}$   | –      | 8    | –    | dBm  | $Z_S = Z_L = 50\ \Omega$ |
| 3rd order intercept point at output | $OIP_3$      | –      | 23   | –    |      | $I_C = 15\text{ mA}$     |

## Electrical Characteristics

 Table 7-8 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 2.4\text{ GHz}$ 

| Parameter                           | Symbol       | Values |      |      | Unit | Note / Test Condition                            |
|-------------------------------------|--------------|--------|------|------|------|--|
|                                     |              | Min.   | Typ. | Max. |      |  |
| <b>Power Gain</b>                   |              |        |      |      |      |  |
| Maximum power gain                  | $G_{ms}$     | –      | 23.5 | –    | dB   | $I_C = 15\text{ mA}$                             |
| Transducer gain                     | $ S_{21} ^2$ | –      | 21.5 | –    |      | $I_C = 15\text{ mA}$                             |
| <b>Minimum Noise Figure</b>         |              |        |      |      |      |  |
| Minimum noise figure                | $NF_{min}$   | –      | 0.5  | –    | dB   | $I_C = 6\text{ mA}$                              |
| Associated gain                     | $G_{ass}$    | –      | 19.5 | –    |      | $I_C = 6\text{ mA}$                              |
| <b>Linearity</b>                    |              |        |      |      |      |  |
| 1 dB compression point at output    | $OP_{1dB}$   | –      | 8    | –    | dBm  | $Z_S = Z_L = 50\ \Omega$<br>$I_C = 15\text{ mA}$ |
| 3rd order intercept point at output | $OIP_3$      | –      | 23   | –    |      | $I_C = 15\text{ mA}$                             |

 Table 7-9 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 3.5\text{ GHz}$ 

| Parameter                           | Symbol       | Values |      |      | Unit | Note / Test Condition                            |
|-------------------------------------|--------------|--------|------|------|------|--|
|                                     |              | Min.   | Typ. | Max. |      |  |
| <b>Power Gain</b>                   |              |        |      |      |      |  |
| Maximum power gain                  | $G_{ms}$     | –      | 22   | –    | dB   | $I_C = 15\text{ mA}$                             |
| Transducer gain                     | $ S_{21} ^2$ | –      | 18.5 | –    |      | $I_C = 15\text{ mA}$                             |
| <b>Minimum Noise Figure</b>         |              |        |      |      |      |  |
| Minimum noise figure                | $NF_{min}$   | –      | 0.6  | –    | dB   | $I_C = 6\text{ mA}$                              |
| Associated gain                     | $G_{ass}$    | –      | 16.5 | –    |      | $I_C = 6\text{ mA}$                              |
| <b>Linearity</b>                    |              |        |      |      |      |  |
| 1 dB compression point at output    | $OP_{1dB}$   | –      | 9    | –    | dBm  | $Z_S = Z_L = 50\ \Omega$<br>$I_C = 15\text{ mA}$ |
| 3rd order intercept point at output | $OIP_3$      | –      | 24.5 | –    |      | $I_C = 15\text{ mA}$                             |

 Table 7-10 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 5.5\text{ GHz}$ 

| Parameter                           | Symbol       | Values |      |      | Unit | Note / Test Condition                            |
|-------------------------------------|--------------|--------|------|------|------|--|
|                                     |              | Min.   | Typ. | Max. |      |  |
| <b>Power Gain</b>                   |              |        |      |      |      |  |
| Maximum power gain                  | $G_{ms}$     | –      | 20   | –    | dB   | $I_C = 15\text{ mA}$                             |
| Transducer gain                     | $ S_{21} ^2$ | –      | 14.5 | –    |      | $I_C = 15\text{ mA}$                             |
| <b>Minimum Noise Figure</b>         |              |        |      |      |      |  |
| Minimum noise figure                | $NF_{min}$   | –      | 0.8  | –    | dB   | $I_C = 6\text{ mA}$                              |
| Associated gain                     | $G_{ass}$    | –      | 13   | –    |      | $I_C = 6\text{ mA}$                              |
| <b>Linearity</b>                    |              |        |      |      |      |  |
| 1 dB compression point at output    | $OP_{1dB}$   | –      | 9.5  | –    | dBm  | $Z_S = Z_L = 50\ \Omega$<br>$I_C = 15\text{ mA}$ |
| 3rd order intercept point at output | $OIP_3$      | –      | 25   | –    |      | $I_C = 15\text{ mA}$                             |



**Electrical Characteristics**
**Table 7-11 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 10\text{ GHz}$** 

| Parameter                           | Symbol       | Values |      |      | Unit | Note / Test Condition                            |
|-------------------------------------|--------------|--------|------|------|------|--|
|                                     |              | Min.   | Typ. | Max. |      |  |
| <b>Power Gain</b>                   |              |        |      |      |      |  |
| Maximum power gain                  | $G_{ma}$     | –      | 13   | –    | dB   | $I_C = 15\text{ mA}$                             |
| Transducer gain                     | $ S_{21} ^2$ | –      | 9    | –    |      | $I_C = 15\text{ mA}$                             |
| <b>Minimum Noise Figure</b>         |              |        |      |      |      |  |
| Minimum noise figure                | $NF_{min}$   | –      | 1.3  | –    | dB   | $I_C = 6\text{ mA}$                              |
| Associated gain                     | $G_{ass}$    | –      | 8.5  | –    |      | $I_C = 6\text{ mA}$                              |
| <b>Linearity</b>                    |              |        |      |      |      |  |
| 1 dB compression point at output    | $OP_{1dB}$   | –      | 9    | –    | dBm  | $Z_S = Z_L = 50\ \Omega$<br>$I_C = 15\text{ mA}$ |
| 3rd order intercept point at output | $OIP_3$      | –      | 24   | –    |      | $I_C = 15\text{ mA}$                             |

**Table 7-12 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 12\text{ GHz}$** 

| Parameter                           | Symbol       | Values |      |      | Unit | Note / Test Condition                            |
|-------------------------------------|--------------|--------|------|------|------|--|
|                                     |              | Min.   | Typ. | Max. |      |  |
| <b>Power Gain</b>                   |              |        |      |      |      |  |
| Maximum power gain                  | $G_{ma}$     | –      | 11   | –    | dB   | $I_C = 15\text{ mA}$                             |
| Transducer gain                     | $ S_{21} ^2$ | –      | 7    | –    |      | $I_C = 15\text{ mA}$                             |
| <b>Minimum Noise Figure</b>         |              |        |      |      |      |  |
| Minimum noise figure                | $NF_{min}$   | –      | 1.5  | –    | dB   | $I_C = 6\text{ mA}$                              |
| Associated gain                     | $G_{ass}$    | –      | 7.5  | –    |      | $I_C = 6\text{ mA}$                              |
| <b>Linearity</b>                    |              |        |      |      |      |  |
| 1 dB compression point at output    | $OP_{1dB}$   | –      | 6.5  | –    | dBm  | $Z_S = Z_L = 50\ \Omega$<br>$I_C = 15\text{ mA}$ |
| 3rd order intercept point at output | $OIP_3$      | –      | 20.5 | –    |      | $I_C = 15\text{ mA}$                             |

Note:  $OIP_3$  value depends on termination of all intermodulation frequency components. Termination used for this measurement is  $50\ \Omega$  from 0.2 MHz to 12 GHz.

7.4 Characteristic DC Diagrams

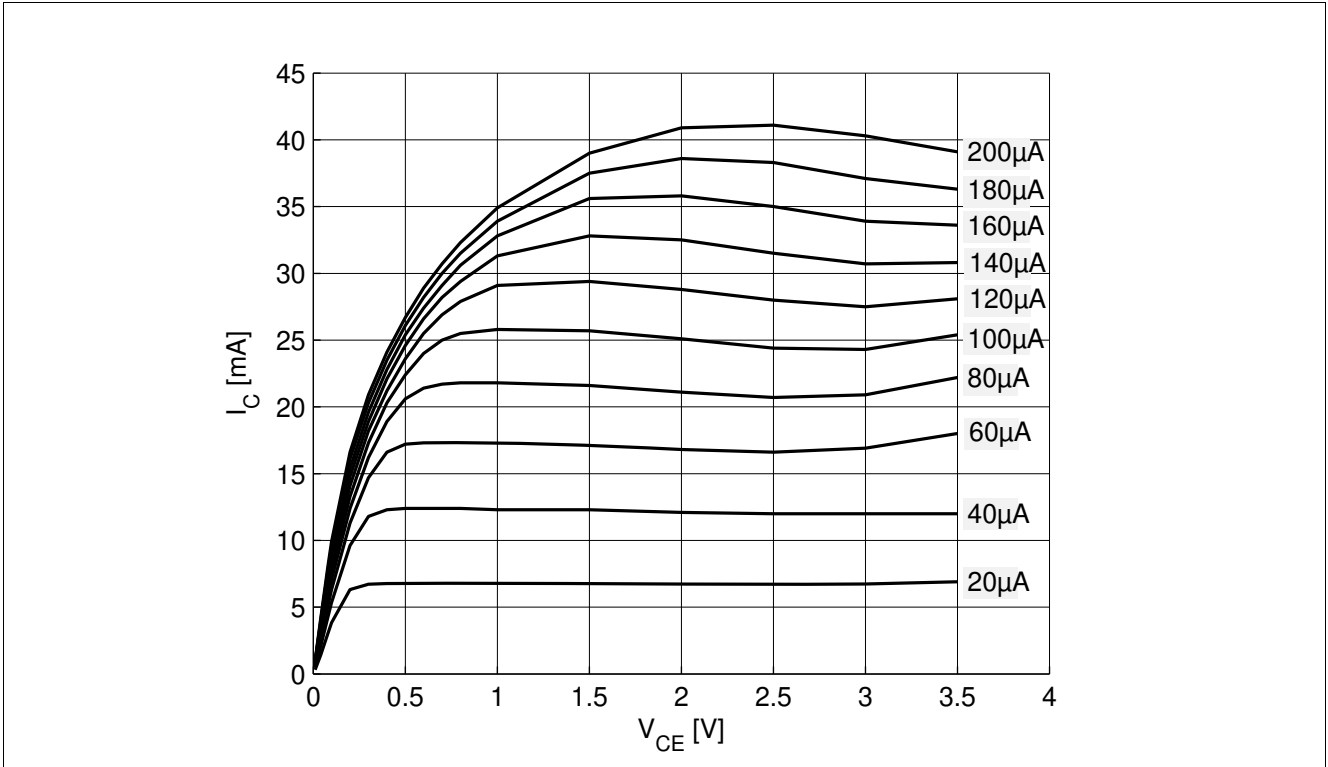


Figure 7-2 Collector Current vs. Collector Emitter Voltage  $I_C = f(V_{CE})$ ,  $I_B = \text{Parameter in } \mu A$

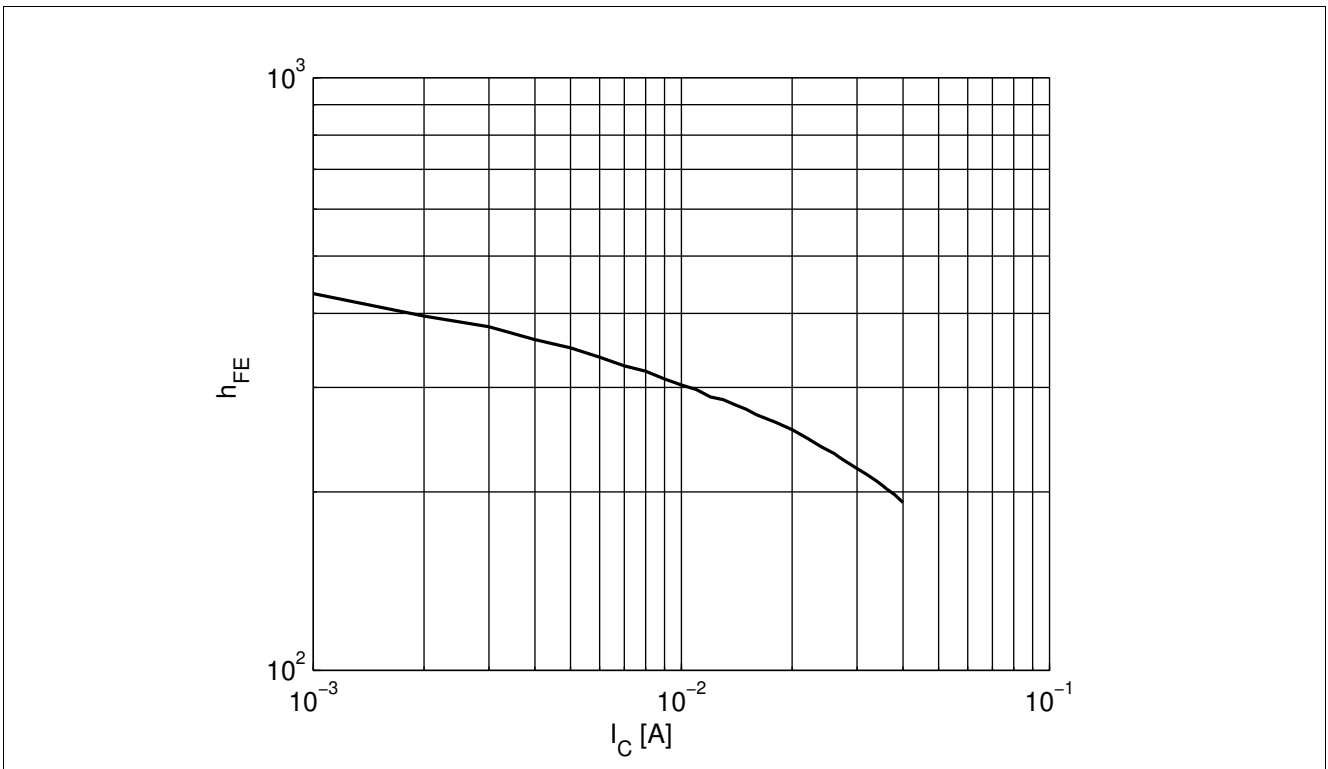


Figure 7-3 DC Current Gain  $h_{FE} = f(I_C)$ ,  $V_{CE} = 3 V$

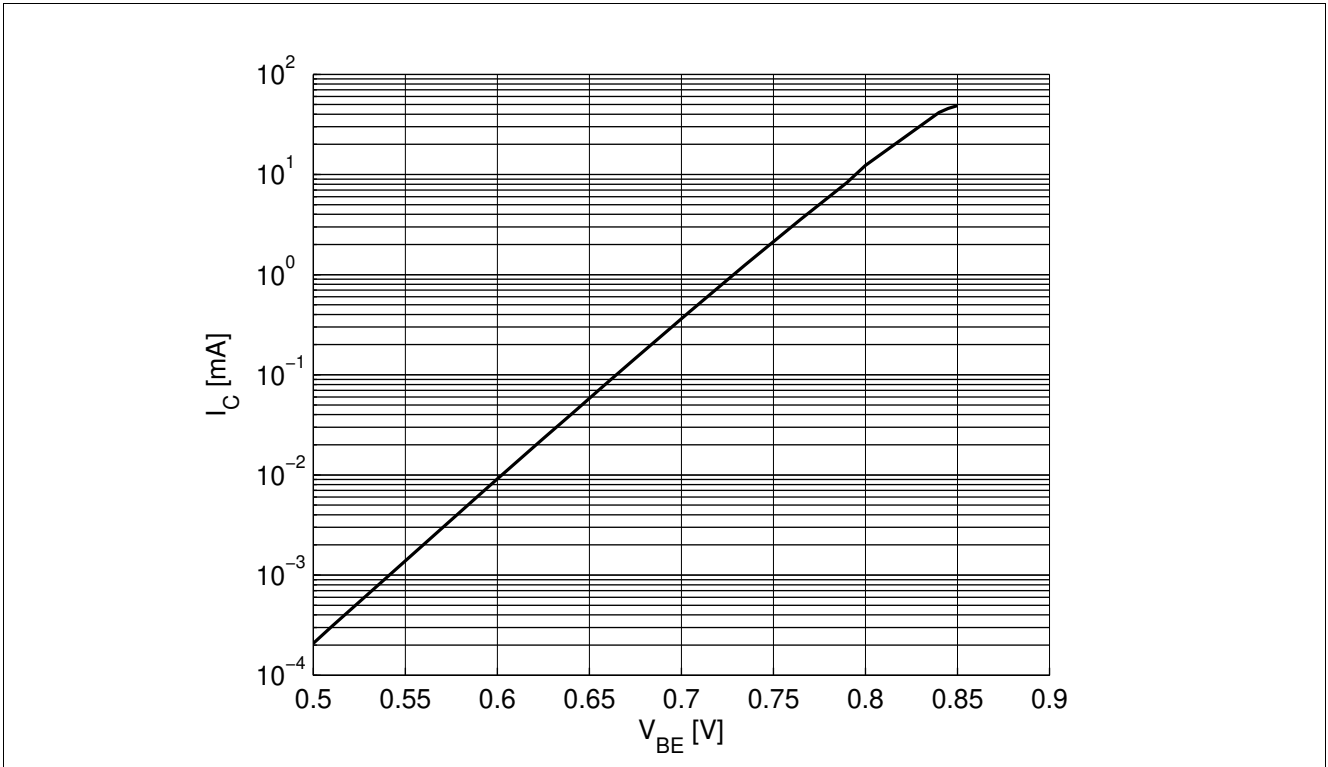


Figure 7-4 Collector Current vs. Base Emitter Forward Voltage  $I_C = f(V_{BE})$ ,  $V_{CE} = 2\text{ V}$

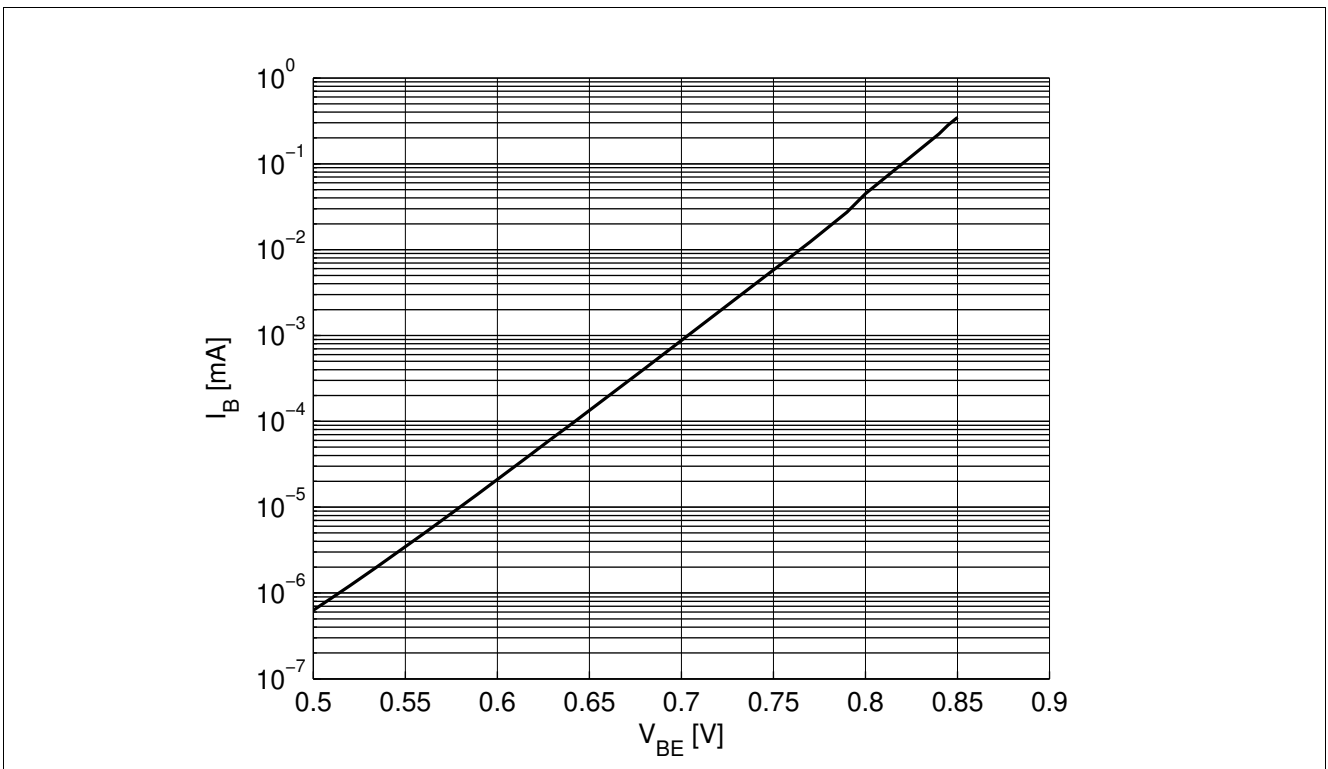


Figure 7-5 Base Current vs. Base Emitter Forward Voltage  $I_B = f(V_{BE})$ ,  $V_{CE} = 2\text{ V}$

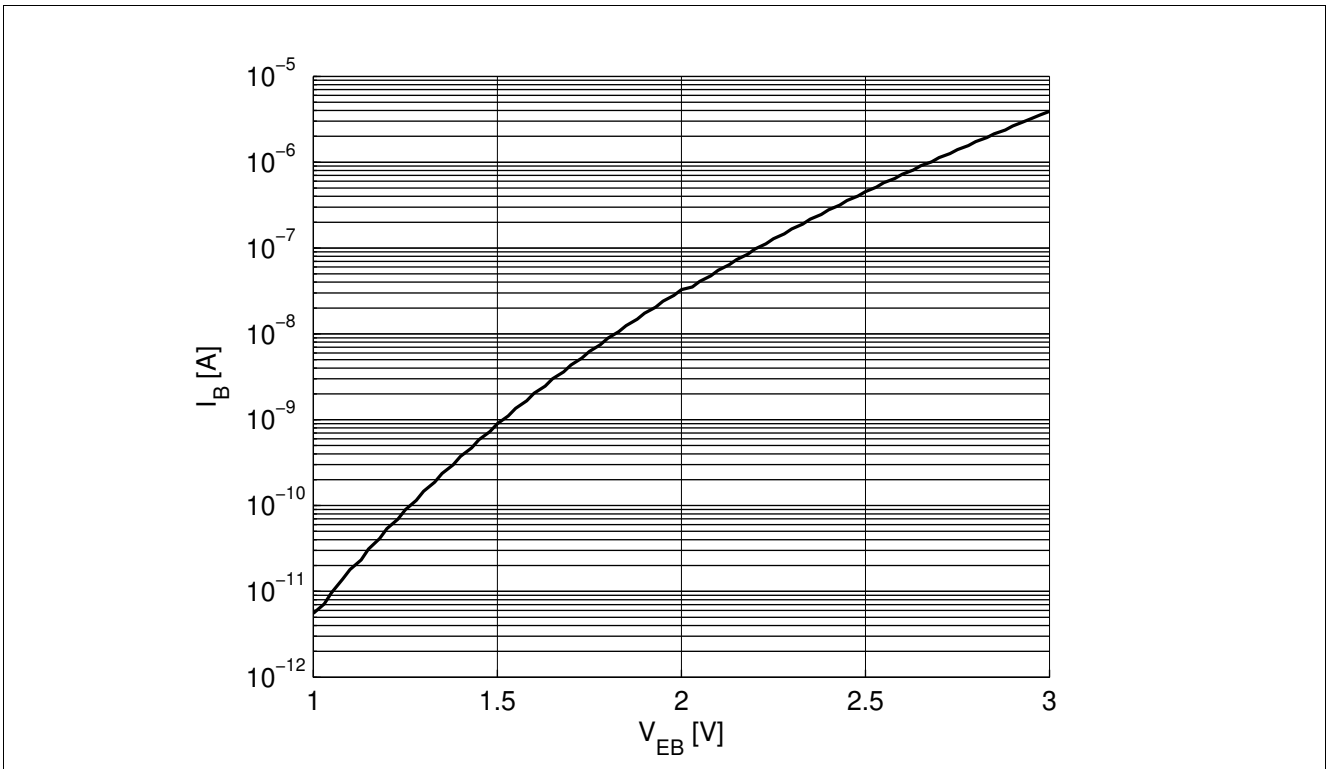


Figure 7-6 Base Current vs. Base Emitter Reverse Voltage  $I_B = f(V_{EB})$ ,  $V_{CE} = 2\text{ V}$



### 7.5 Characteristic AC Diagrams

Measurement setup is a test fixture with Bias-T's in a 50 Ω system,  $T_A = 25\text{ °C}$ .

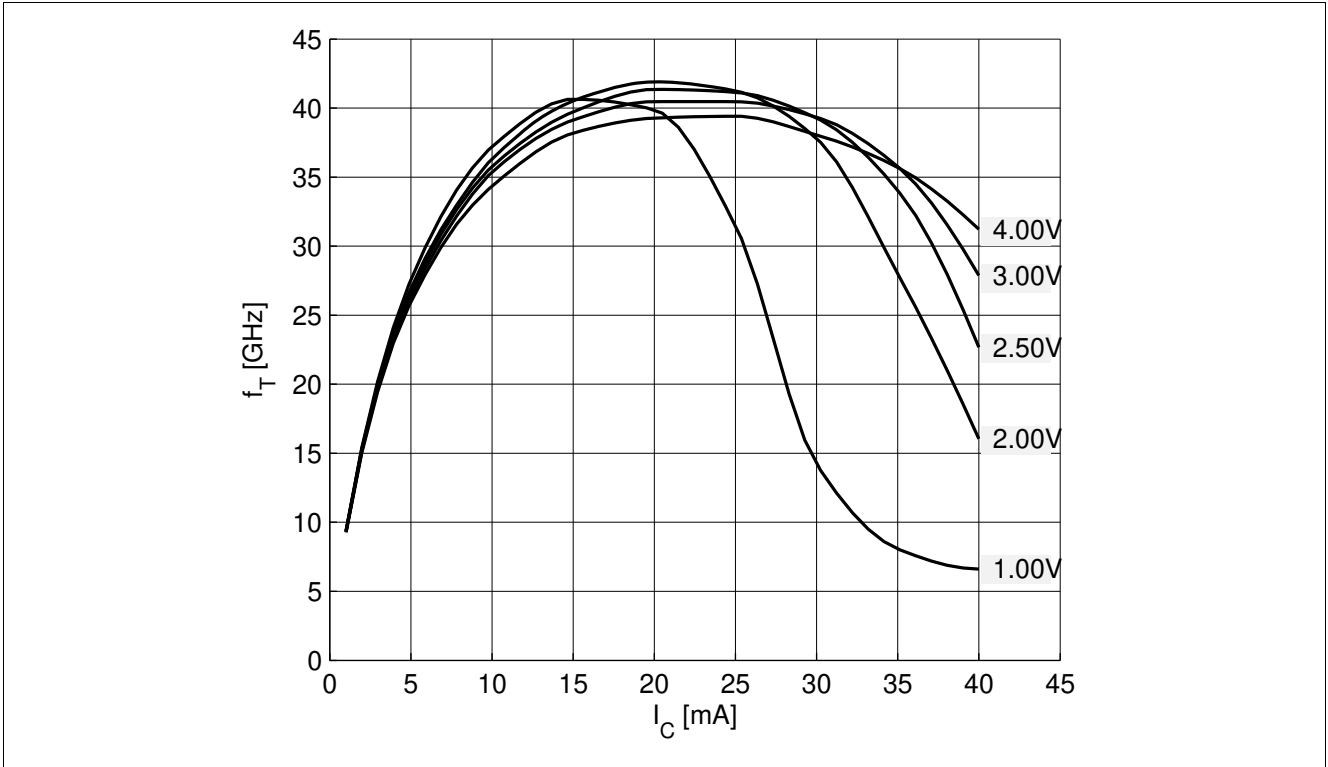


Figure 7-7 Transition Frequency  $f_T = f(I_C)$ ,  $f = 2\text{ GHz}$ ,  $V_{CE} = \text{Parameter in V}$

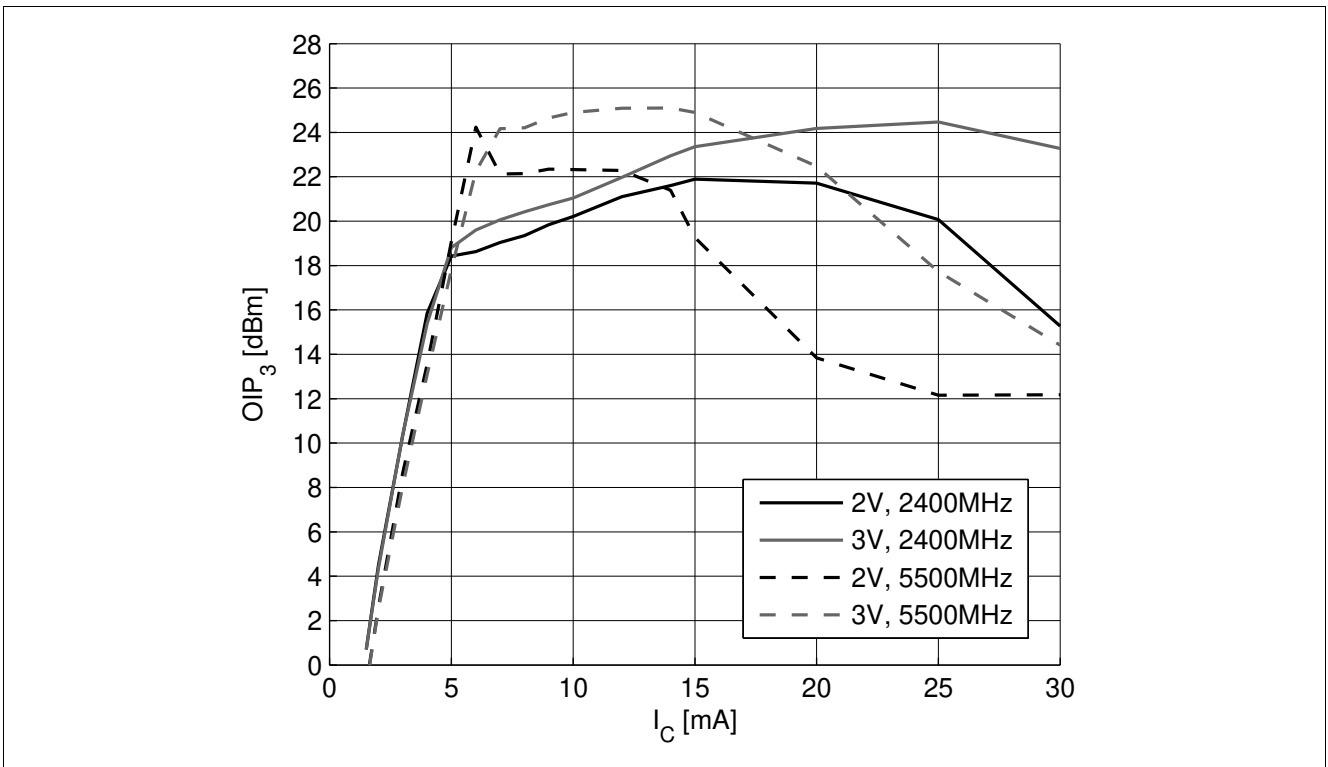


Figure 7-8 3rd Order Intercept Point at output  $OIP_3 = f(I_C)$ ,  $Z_S = Z_L = 50\text{ }\Omega$ ,  $V_{CE}, f = \text{Parameters}$

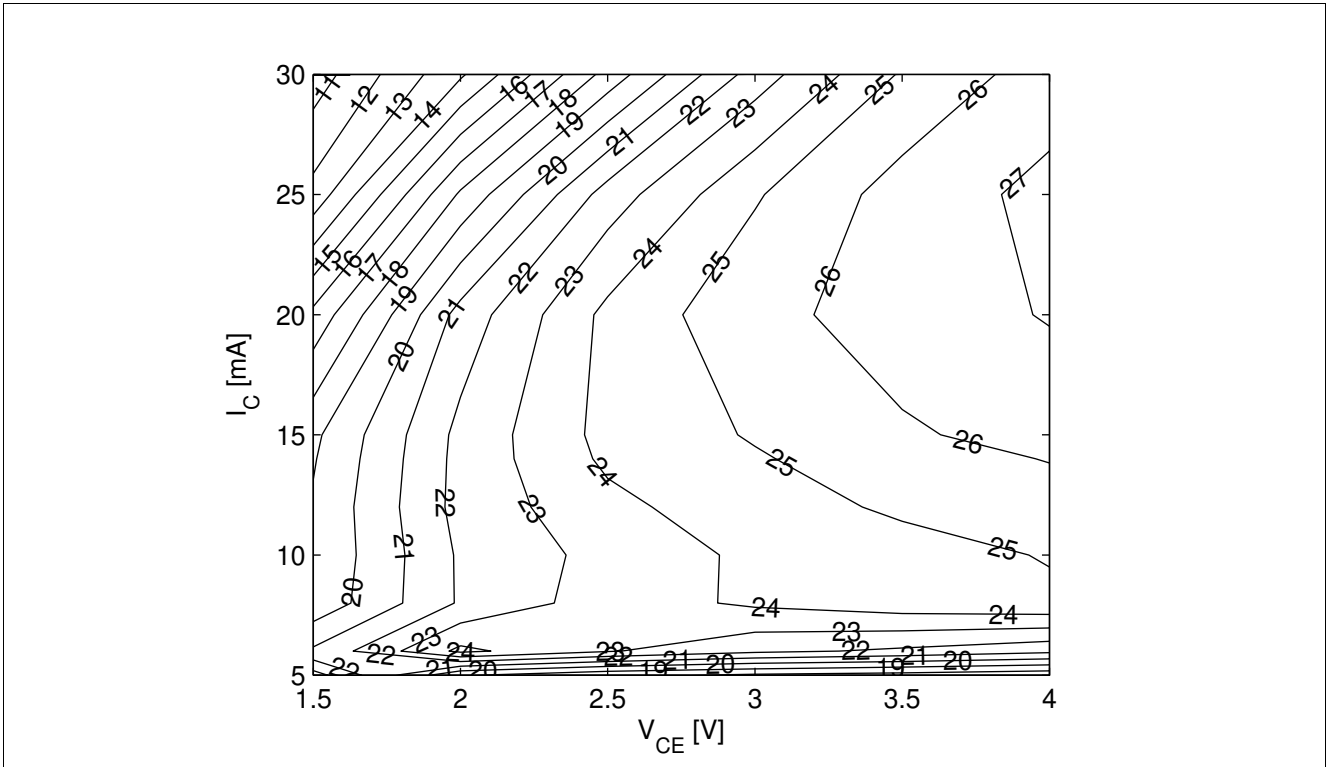


Figure 7-9 3rd Order Intercept Point at output  $OIP_3$  [dBm] =  $f(I_C, V_{CE})$ ,  $Z_S = Z_L = 50 \Omega$ ,  $f = 5.5$  GHz

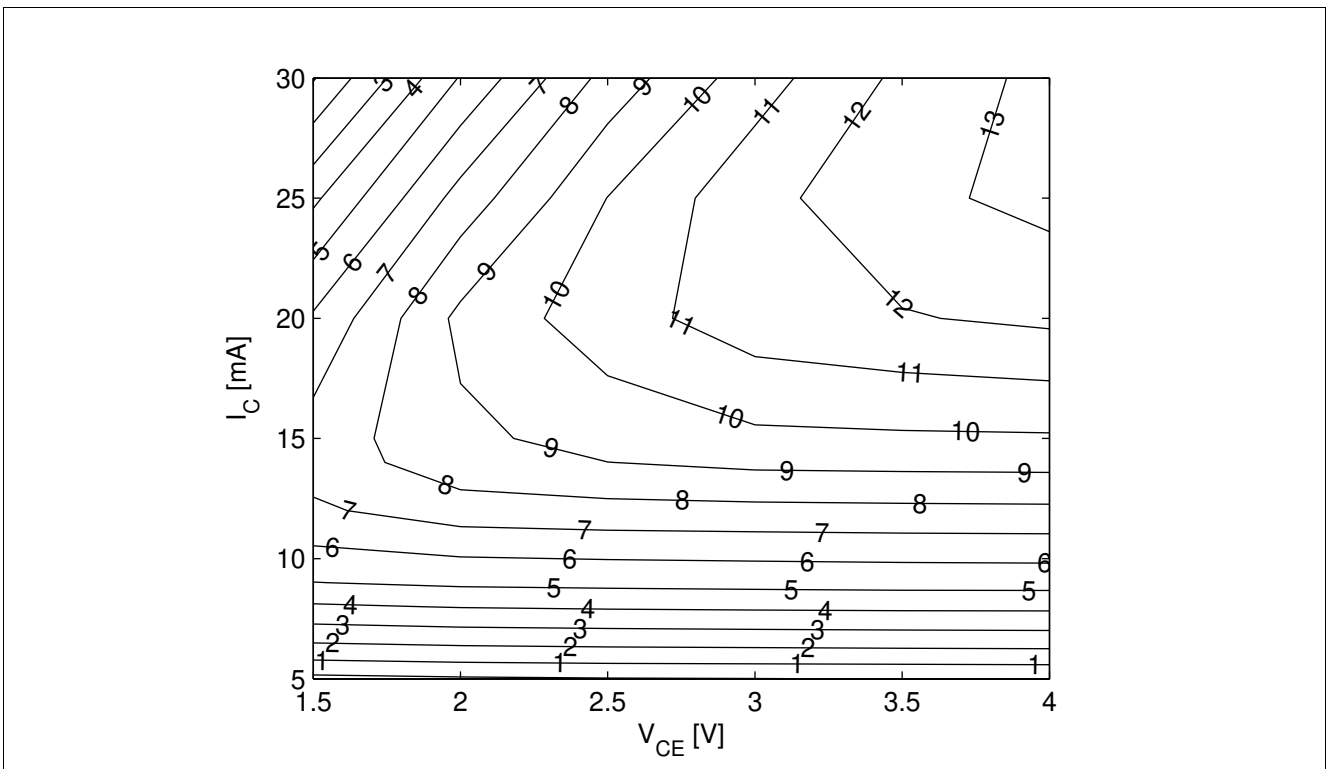


Figure 7-10 Compression Point at output  $OP_{1dB}$  [dBm] =  $f(I_C, V_{CE})$ ,  $Z_S = Z_L = 50 \Omega$ ,  $f = 5.5$  GHz

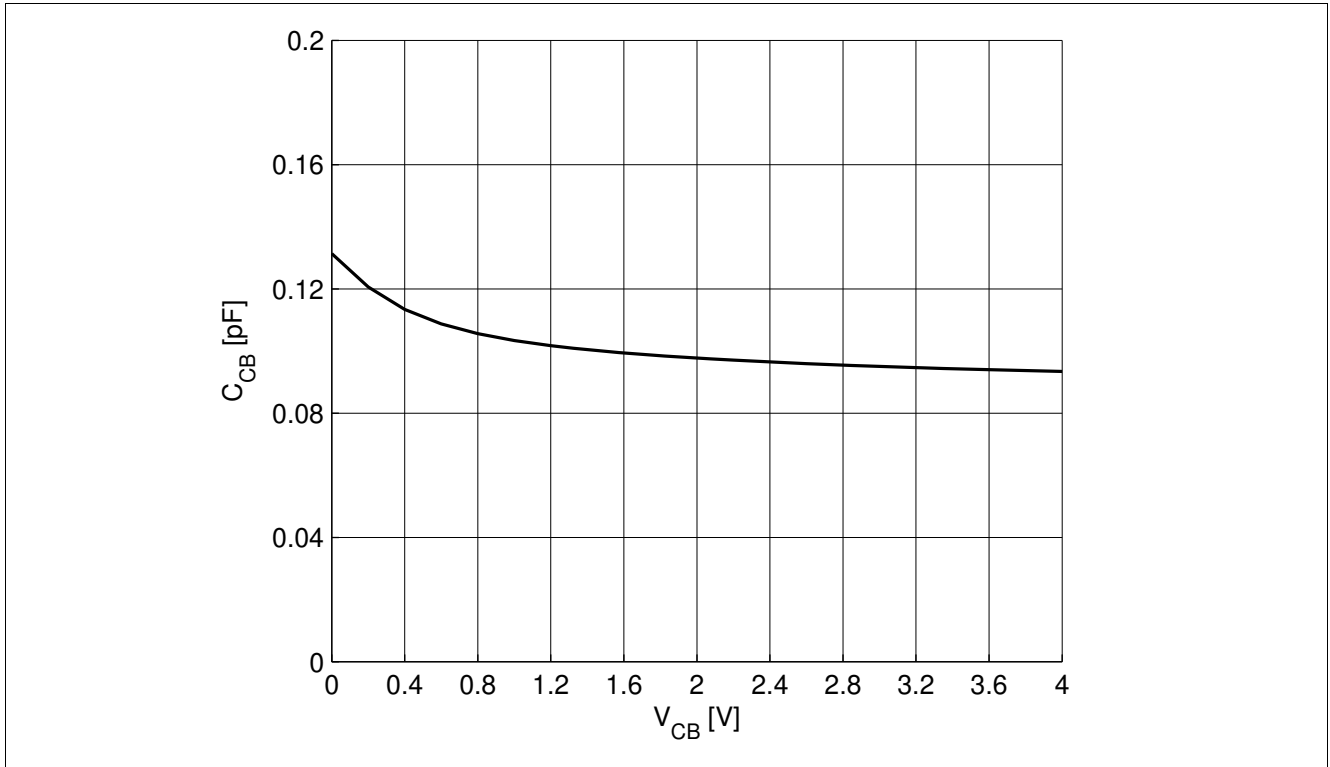


Figure 7-11 Collector Base Capacitance  $C_{CB} = f(V_{CB}), f = 1$  MHz

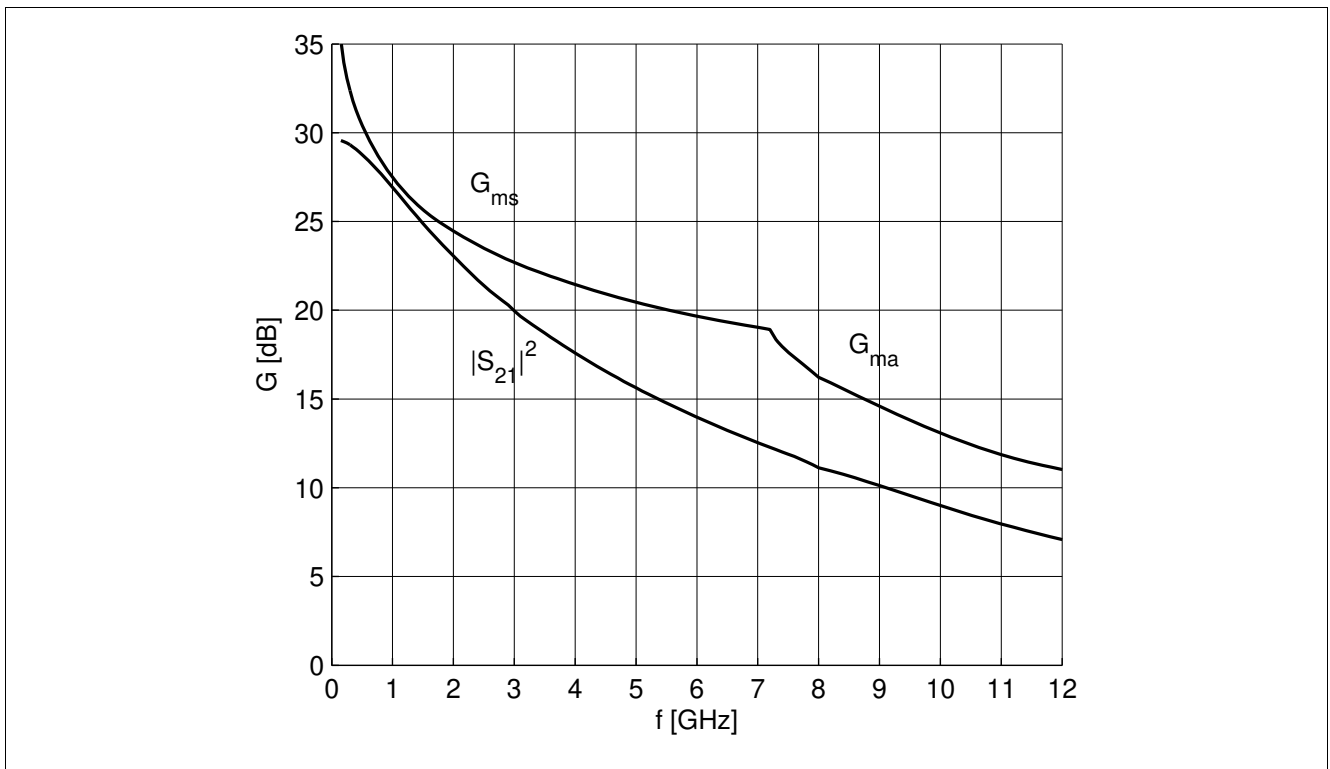


Figure 7-12 Gain  $G_{ma}, G_{ms}, |S_{21}|^2 = f(f), V_{CE} = 3$  V,  $I_C = 15$  mA

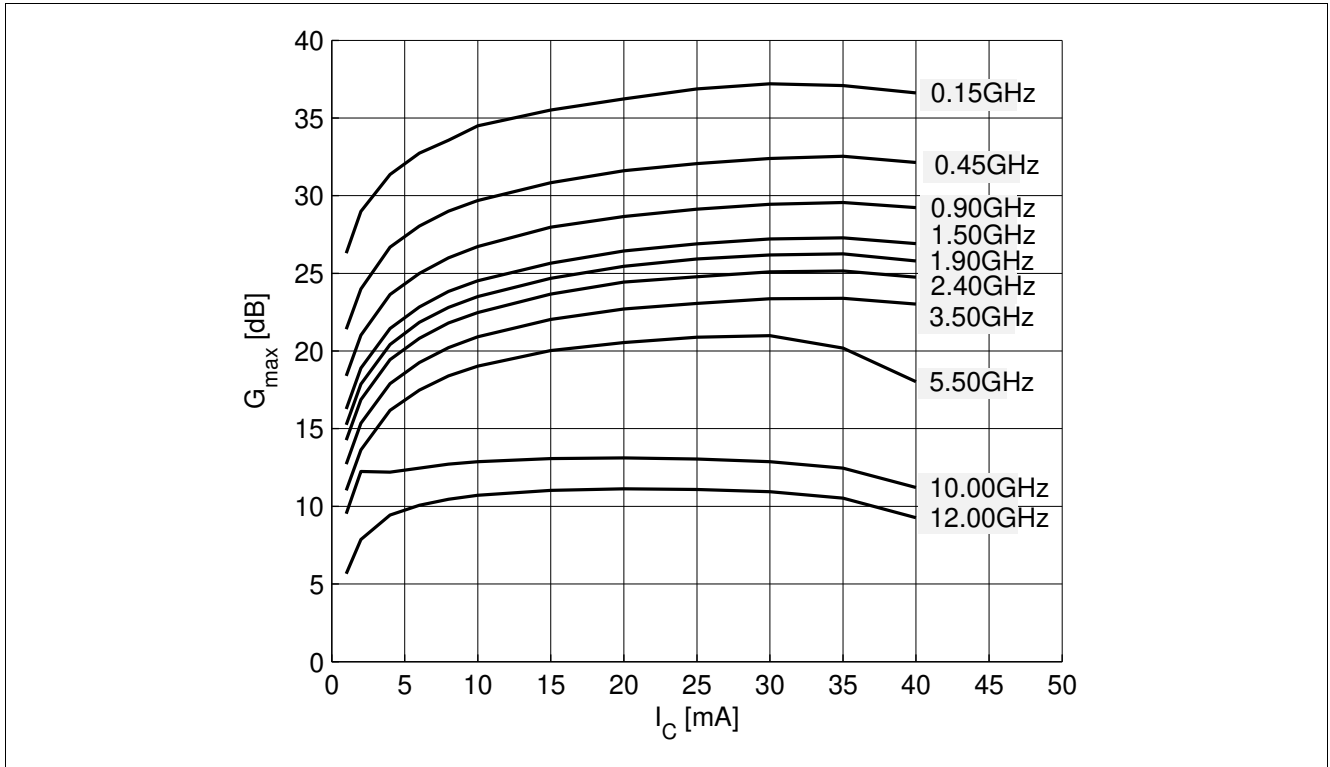


Figure 7-13 Maximum Power Gain  $G_{max} = f(I_C)$ ,  $V_{CE} = 3\text{ V}$ ,  $f = \text{Parameter in GHz}$

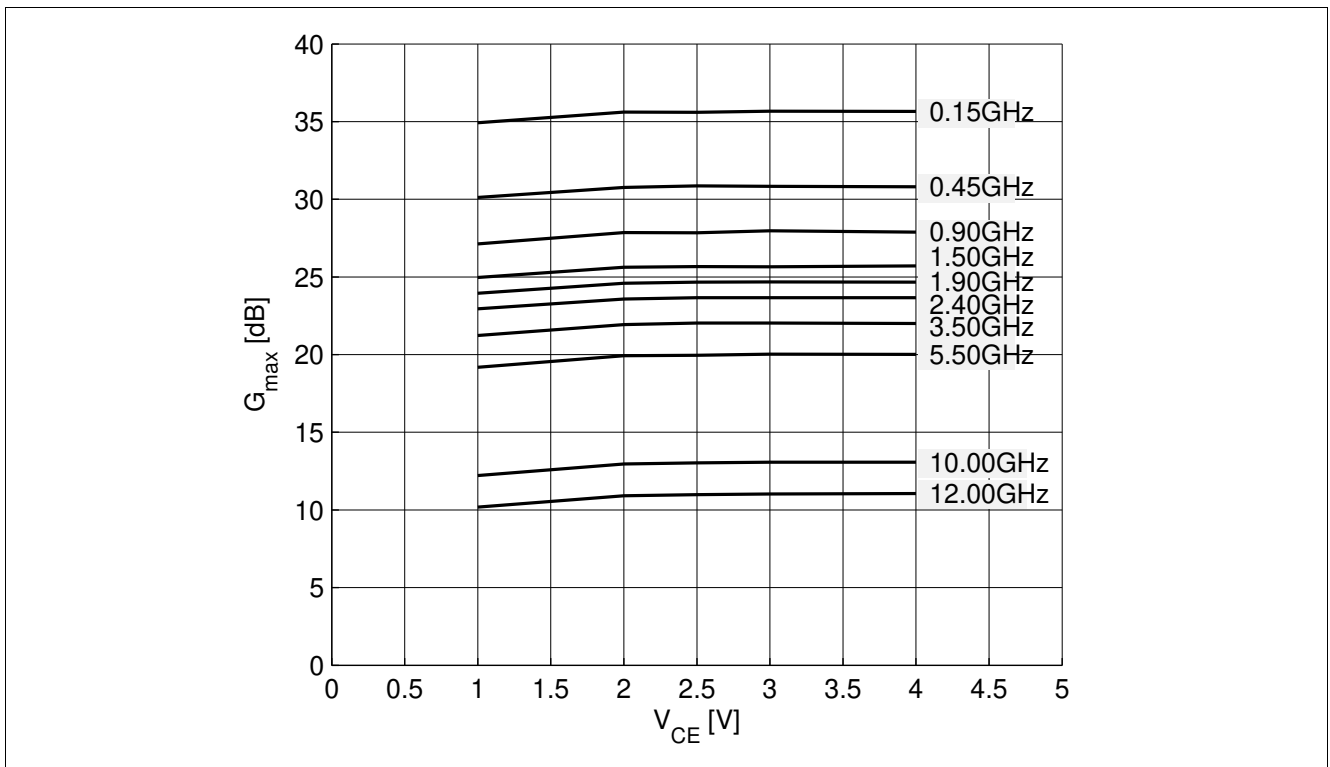


Figure 7-14 Maximum Power Gain  $G_{max} = f(V_{CE})$ ,  $I_C = 15\text{ mA}$ ,  $f = \text{Parameter in GHz}$

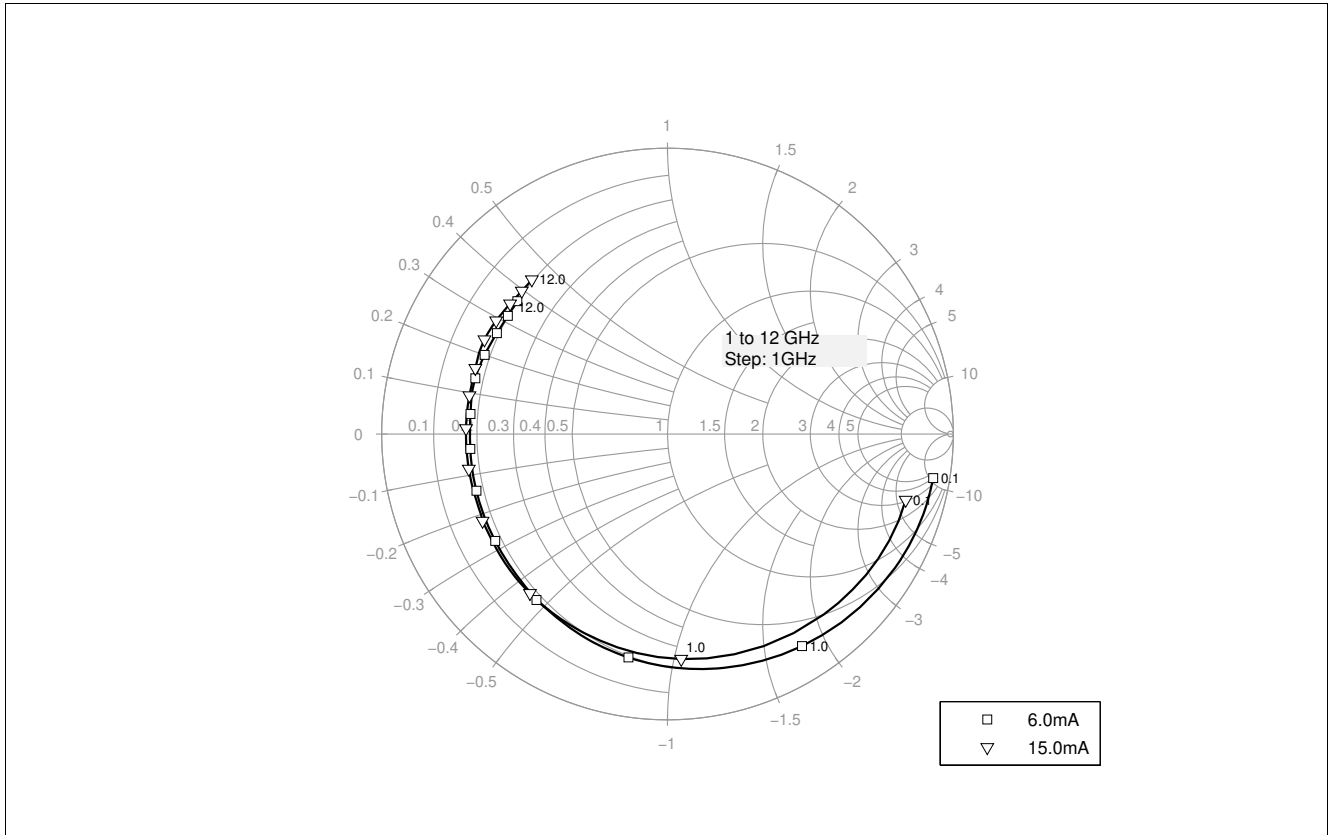


Figure 7-15 Input Matching  $S_{11} = f(f)$ ,  $V_{CE} = 3\text{ V}$ ,  $I_C = 6 / 15\text{ mA}$

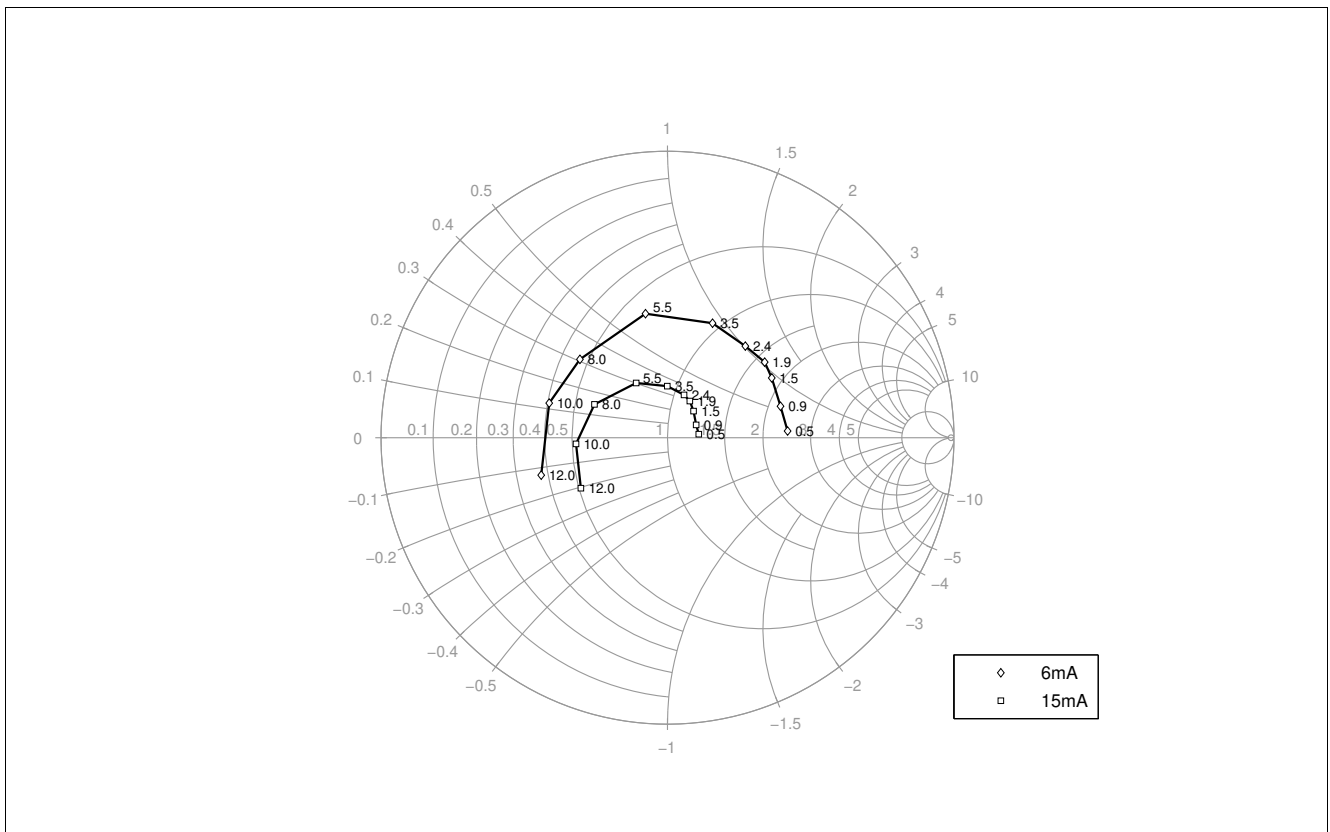


Figure 7-16 Source Impedance for Minimum Noise Figure  $Z_{opt} = f(f)$ ,  $V_{CE} = 3\text{ V}$ ,  $I_C = 6 / 15\text{ mA}$

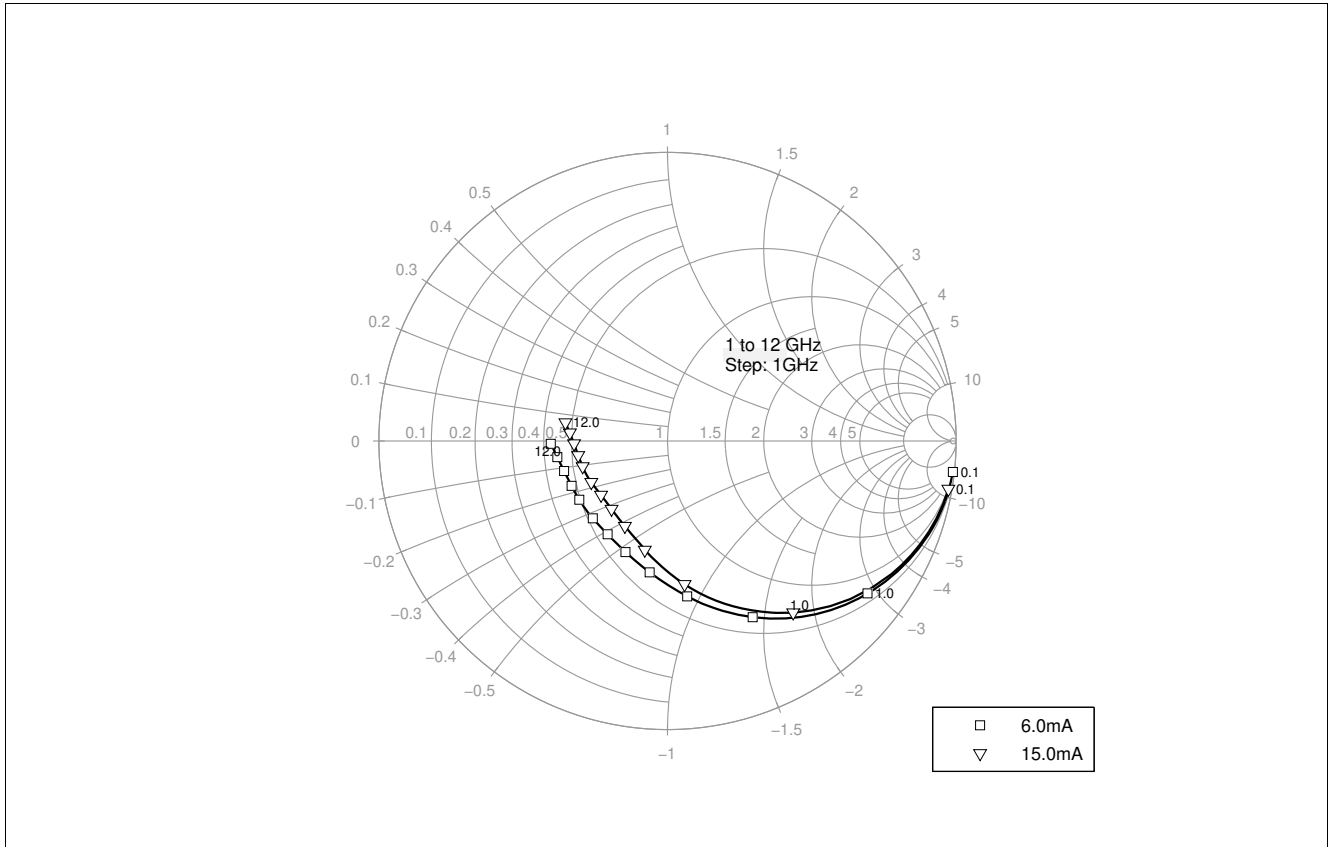


Figure 7-17 Output Matching  $S_{22} = f(f)$ ,  $V_{CE} = 3\text{ V}$ ,  $I_C = 6 / 15\text{ mA}$

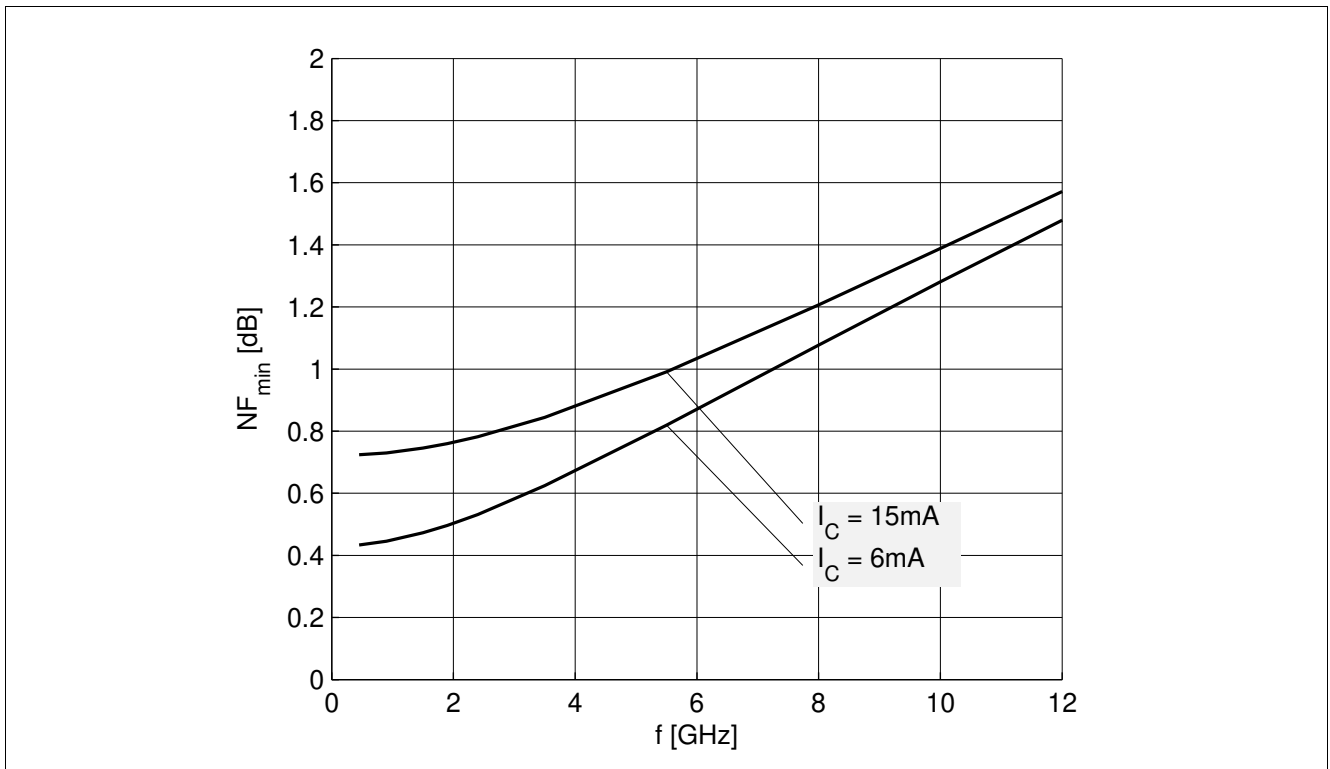


Figure 7-18 Noise Figure  $NF_{min} = f(f)$ ,  $V_{CE} = 3\text{ V}$ ,  $I_C = 6 / 15\text{ mA}$ ,  $Z_S = Z_{opt}$