

# BFU668F

NPN wideband silicon RF transistor

Rev. 3 — 24 January 2012

Product data sheet

## 1. Product profile

### 1.1 General description

NPN silicon microwave transistor in a plastic, 4-pin dual-emitter SOT343F package offering an innovative Ku-band DRO solution.

#### CAUTION



This device is sensitive to ElectroStatic Discharge (ESD). Observe precautions for handling electrostatic sensitive devices.

Such precautions are described in the *ANSI/ESD S20.20*, *IEC/ST 61340-5*, *JESD625-A* or equivalent standards.

### 1.2 Features and benefits

- DROs with good output power and low phase noise at very low current consumption: 5 dBm and  $-55$  dBc/Hz/1 kHz at 12 mA
- Low-noise, high gain for low cost LNA solutions
- 40 GHz  $f_T$  silicon technology

### 1.3 Applications

- Ku-band DROs in Ku-band LNBS
- C-band, low current LNAs



## 1.4 Quick reference data

**Table 1. Quick reference data**

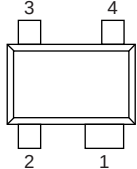
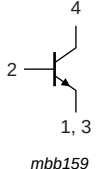
| Symbol         | Parameter                                  | Conditions                                                                                                                               | Min | Typ | Max  | Unit |
|----------------|--------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|------|------|
| $V_{CBO}$      | collector-base voltage                     | open emitter                                                                                                                             | -   | -   | 16   | V    |
| $V_{CEO}$      | collector-emitter voltage                  | open base                                                                                                                                | -   | -   | 5.5  | V    |
| $V_{EBO}$      | emitter-base voltage                       | open collector                                                                                                                           | -   | -   | 2.5  | V    |
| $I_C$          | collector current                          |                                                                                                                                          | -   | 15  | 40   | mA   |
| $P_{tot}$      | total power dissipation                    | $T_{sp} \leq 90\text{ °C}$                                                                                                               | [1] | -   | 200  | mW   |
| $h_{FE}$       | DC current gain                            | $I_C = 10\text{ mA}$ ; $V_{CE} = 3.5\text{ V}$ ;<br>$T_j = 25\text{ °C}$                                                                 | 90  | 135 | 200  |      |
| $C_{CBS}$      | collector-base capacitance                 | $V_{CB} = 2\text{ V}$ ; $f = 1\text{ MHz}$                                                                                               | -   | 138 | -    | fF   |
| $f_T$          | transition frequency                       | $I_C = 15\text{ mA}$ ; $V_{CE} = 3.5\text{ V}$ ;<br>$f = 2\text{ GHz}$ ; $T_{amb} = 25\text{ °C}$                                        | -   | 20  | -    | GHz  |
| $IP3_{o(max)}$ | maximum output third-order intercept point | $I_C = 15\text{ mA}$ ; $V_{CE} = 3.5\text{ V}$ ;<br>$f = 10\text{ GHz}$ ; $T_{amb} = 25\text{ °C}$ ;<br>$Z_S = Z_L = 50\text{ }\Omega$ ; | -   | 24  | -    | dBm  |
| $G_{p(max)}$   | maximum power gain                         | $I_C = 15\text{ mA}$ ; $V_{CE} = 3.5\text{ V}$ ;<br>$f = 10.0\text{ GHz}$ ;<br>$T_{amb} = 25\text{ °C}$                                  | [2] | -   | 10.5 | dB   |
| NF             | noise figure                               | $I_C = 15\text{ mA}$ ; $V_{CE} = 3.5\text{ V}$ ;<br>$f = 10.0\text{ GHz}$ ; $\Gamma_S = \Gamma_{opt}$ ;<br>$T_{amb} = 25\text{ °C}$      | -   | 1.7 | -    | dB   |
| $P_{L(1dB)}$   | output power at 1 dB gain compression      | $I_C = 15\text{ mA}$ ; $V_{CE} = 3.5\text{ V}$ ;<br>$Z_S = Z_L = 50\text{ }\Omega$ ;<br>$f = 10\text{ GHz}$ ; $T_{amb} = 25\text{ °C}$   | -   | 12  | -    | dBm  |

[1]  $T_{sp}$  is the temperature at the solder point of the emitter lead.

[2]  $G_{p(max)}$  is the maximum power gain, if  $K > 1$ . If  $K < 1$  then  $G_{p(max)} = MSG$ .

## 2. Pinning information

**Table 2. Discrete pinning**

| Pin | Description | Simplified outline                                                                    | Graphic symbol                                                                        |
|-----|-------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| 1   | emitter     |  |  |
| 2   | base        |                                                                                       |                                                                                       |
| 3   | emitter     |                                                                                       |                                                                                       |
| 4   | collector   |                                                                                       |                                                                                       |

### 3. Ordering information

Table 3. Ordering information

| Type number | Package |                                                                     |         |
|-------------|---------|---------------------------------------------------------------------|---------|
|             | Name    | Description                                                         | Version |
| BFU668F     | -       | plastic surface-mounted flat pack package; reverse pinning; 4 leads | SOT343F |

### 4. Marking

Table 4. Marking

| Type number | Marking | Description                                                                    |
|-------------|---------|--------------------------------------------------------------------------------|
| BFU668F     | ZA*     | * = p : made in Hong Kong<br>* = t : made in Malaysia<br>* = w : made in China |

### 5. Limiting values

Table 5. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134).

| Symbol    | Parameter                 | Conditions                 | Min                   | Max  | Unit |
|-----------|---------------------------|----------------------------|-----------------------|------|------|
| $V_{CBO}$ | collector-base voltage    | open emitter               | -                     | 16   | V    |
| $V_{CEO}$ | collector-emitter voltage | open base                  | -                     | 5.5  | V    |
| $V_{EBO}$ | emitter-base voltage      | open collector             | -                     | 2.5  | V    |
| $I_C$     | collector current         |                            | -                     | 40   | mA   |
| $P_{tot}$ | total power dissipation   | $T_{sp} \leq 90\text{ °C}$ | <a href="#">[1]</a> - | 200  | mW   |
| $T_{stg}$ | storage temperature       |                            | -65                   | +150 | °C   |
| $T_j$     | junction temperature      |                            | -                     | 150  | °C   |

[1]  $T_{sp}$  is the temperature at the solder point of the emitter lead.

### 6. Thermal characteristics

Table 6. Thermal characteristics

| Symbol         | Parameter                                        | Conditions | Typ | Unit |
|----------------|--------------------------------------------------|------------|-----|------|
| $R_{th(j-sp)}$ | thermal resistance from junction to solder point |            | 270 | K/W  |

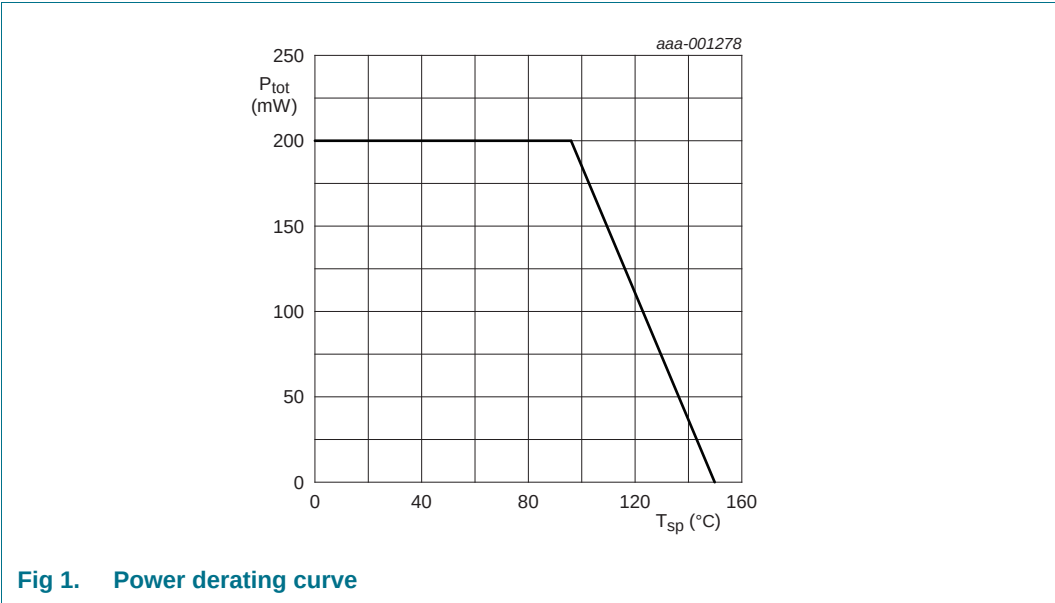


Fig 1. Power derating curve

## 7. Characteristics

**Table 7. Characteristics**

$T_j = 25\text{ °C}$  unless otherwise specified

| Symbol         | Parameter                                  | Conditions                                                                                                 | Min | Typ  | Max | Unit |
|----------------|--------------------------------------------|------------------------------------------------------------------------------------------------------------|-----|------|-----|------|
| $V_{(BR)CBO}$  | collector-base breakdown voltage           | $I_C = 2.5\text{ }\mu\text{A}$ ; $I_E = 0\text{ mA}$                                                       | 16  | -    | -   | V    |
| $V_{(BR)CEO}$  | collector-emitter breakdown voltage        | $I_C = 1\text{ mA}$ ; $I_B = 0\text{ mA}$                                                                  | 5.5 | -    | -   | V    |
| $I_C$          | collector current                          |                                                                                                            | -   | 15   | 40  | mA   |
| $I_{CBO}$      | collector-base cut-off current             | $I_E = 0\text{ mA}$ ; $V_{CB} = 8\text{ V}$                                                                | -   | -    | 100 | nA   |
| $h_{FE}$       | DC current gain                            | $I_C = 10\text{ mA}$ ; $V_{CE} = 3.5\text{ V}$                                                             | 90  | 135  | 200 |      |
| $C_{CES}$      | collector-emitter capacitance              | $V_{CB} = 2\text{ V}$ ; $f = 1\text{ MHz}$                                                                 | -   | 297  | -   | fF   |
| $C_{EBS}$      | emitter-base capacitance                   | $V_{EB} = 0.5\text{ V}$ ; $f = 1\text{ MHz}$                                                               | -   | 664  | -   | fF   |
| $C_{CBS}$      | collector-base capacitance                 | $V_{CB} = 2\text{ V}$ ; $f = 1\text{ MHz}$                                                                 | -   | 138  | -   | fF   |
| $f_T$          | transition frequency                       | $I_C = 15\text{ mA}$ ; $V_{CE} = 3.5\text{ V}$ ; $f = 2\text{ GHz}$ ; $T_{amb} = 25\text{ °C}$             | -   | 20   | -   | GHz  |
| $G_{p(max)}$   | maximum power gain                         | $I_C = 15\text{ mA}$ ; $V_{CE} = 3.5\text{ V}$ ; $T_{amb} = 25\text{ °C}$ <a href="#">[1]</a>              |     |      |     |      |
|                |                                            | $f = 5.8\text{ GHz}$                                                                                       | -   | 14.5 | -   | dB   |
|                |                                            | $f = 10.0\text{ GHz}$                                                                                      | -   | 10.5 | -   | dB   |
| $ S_{21} ^2$   | insertion power gain                       | $I_C = 15\text{ mA}$ ; $V_{CE} = 3.5\text{ V}$ ; $T_{amb} = 25\text{ °C}$                                  |     |      |     |      |
|                |                                            | $f = 5.8\text{ GHz}$                                                                                       | -   | 9.5  | -   | dB   |
|                |                                            | $f = 10.0\text{ GHz}$                                                                                      | -   | 5.0  | -   | dB   |
| NF             | noise figure                               | $I_C = 15\text{ mA}$ ; $V_{CE} = 3.5\text{ V}$ ; $\Gamma_S = \Gamma_{opt}$ ; $T_{amb} = 25\text{ °C}$      |     |      |     |      |
|                |                                            | $f = 5.8\text{ GHz}$                                                                                       | -   | 1.3  | -   | dB   |
|                |                                            | $f = 10.0\text{ GHz}$                                                                                      | -   | 1.7  | -   | dB   |
| $G_{ass}$      | associated gain                            | $I_C = 15\text{ mA}$ ; $V_{CE} = 3.5\text{ V}$ ; $\Gamma_S = \Gamma_{opt}$ ; $T_{amb} = 25\text{ °C}$      |     |      |     |      |
|                |                                            | $f = 5.8\text{ GHz}$                                                                                       | -   | 13   | -   | dB   |
|                |                                            | $f = 10.0\text{ GHz}$                                                                                      | -   | 9.5  | -   | dB   |
| $P_{L(1dB)}$   | output power at 1 dB gain compression      | $I_C = 15\text{ mA}$ ; $V_{CE} = 3.5\text{ V}$ ; $Z_S = Z_L = 50\text{ }\Omega$ ; $T_{amb} = 25\text{ °C}$ |     |      |     |      |
|                |                                            | $f = 5.8\text{ GHz}$                                                                                       | -   | 13   | -   | dBm  |
|                |                                            | $f = 10.0\text{ GHz}$                                                                                      | -   | 12   | -   | dBm  |
| $IP3_{o(max)}$ | maximum output third-order intercept point | $I_C = 15\text{ mA}$ ; $V_{CE} = 3.5\text{ V}$ ; $Z_S = Z_L = 50\text{ }\Omega$ ; $T_{amb} = 25\text{ °C}$ |     |      |     |      |
|                |                                            | $f = 5.8\text{ GHz}$                                                                                       | -   | 24   | -   | dBm  |
|                |                                            | $f = 10.0\text{ GHz}$                                                                                      | -   | 24   | -   | dBm  |

[1]  $G_{p(max)}$  is the maximum power gain, if  $K > 1$ . If  $K < 1$  then  $G_{p(max)} = MSG$ .

## 8. Application information

### 8.1 BFU668F Ku-band Dielectric Resonator Oscillator (DRO)

[Figure 2](#) shows a typical DRO circuit using BFU668F as active device. The schematic highlights the bias elements. Evaluation tests, done by replacing the existing transistor with BFU668F, on three different DRO LNBs / configurations, have proven:

- BFU668F achieves similar Phase Noise and RF power as the replaced transistor
- BFU668F achieves same RF performances at approximately half of the bias current

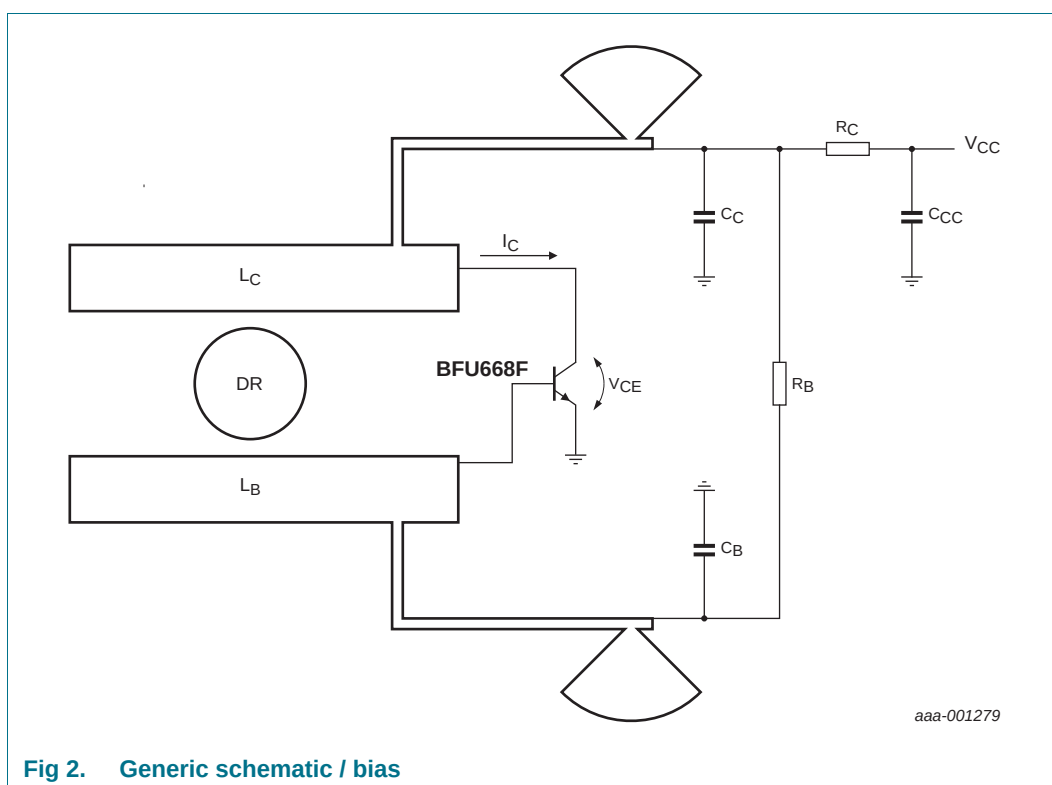
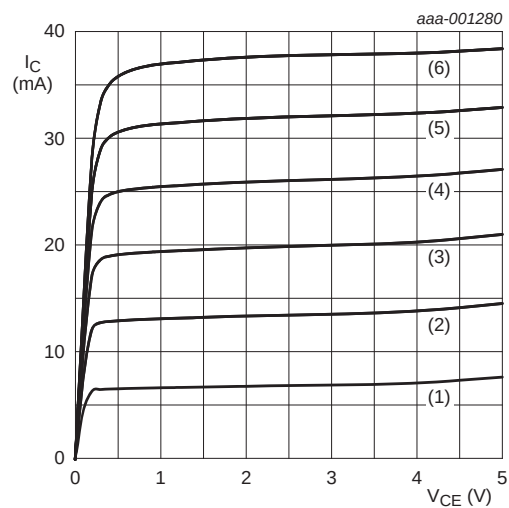


Fig 2. Generic schematic / bias

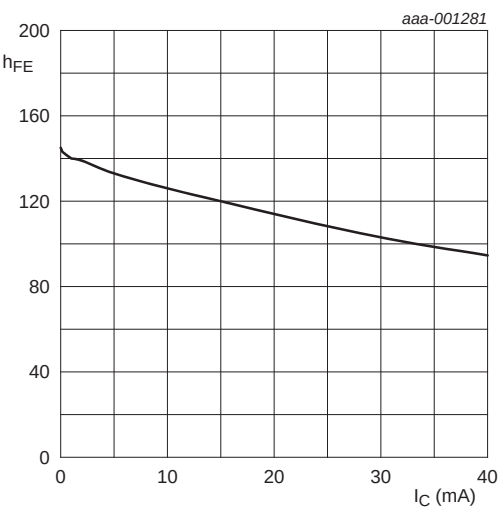
8.2 Graphs



$T_{amb} = 25\text{ }^{\circ}\text{C}.$

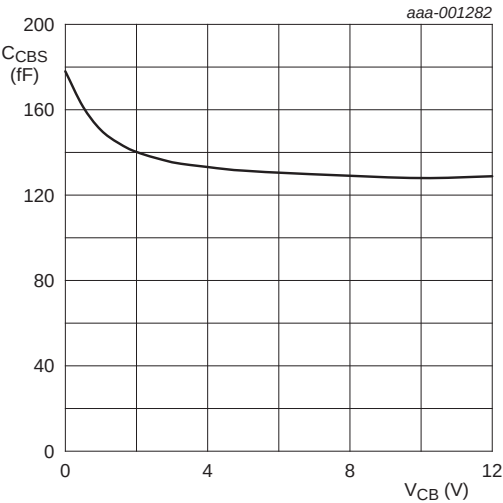
- (1)  $I_B = 50\text{ }\mu\text{A}$
- (2)  $I_B = 100\text{ }\mu\text{A}$
- (3)  $I_B = 150\text{ }\mu\text{A}$
- (4)  $I_B = 200\text{ }\mu\text{A}$
- (5)  $I_B = 250\text{ }\mu\text{A}$
- (6)  $I_B = 300\text{ }\mu\text{A}$

Fig 3. Collector current as a function of collector-emitter voltage; typical values



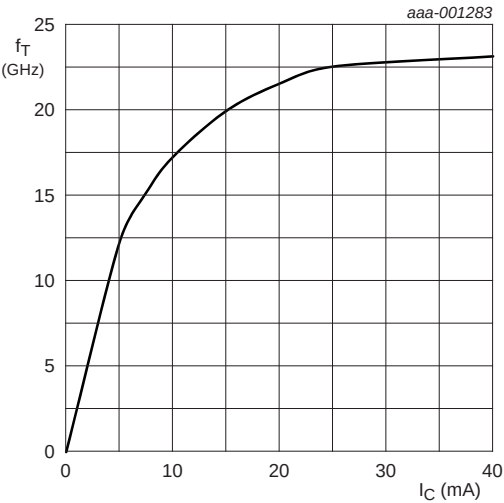
$V_{CE} = 2\text{ V}; T_{amb} = 25\text{ }^{\circ}\text{C}.$

Fig 4. DC current gain as a function of collector current; typical values



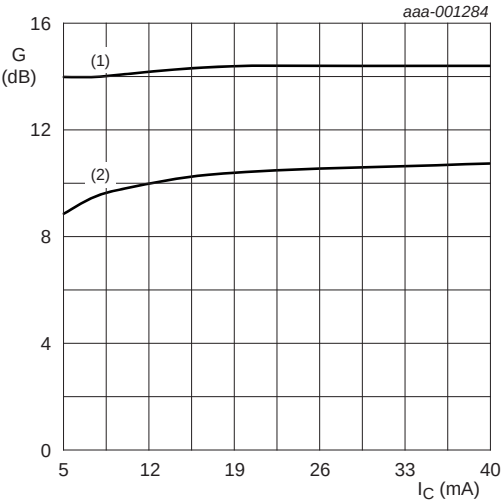
$f = 1\text{ MHz}$ ,  $T_{amb} = 25\text{ }^{\circ}\text{C}$ .

Fig 5. Collector-base capacitance as a function of collector-base voltage; typical values



$V_{CE} = 3.5\text{ V}$ ;  $f = 2\text{ GHz}$ ;  $T_{amb} = 25\text{ }^{\circ}\text{C}$ .

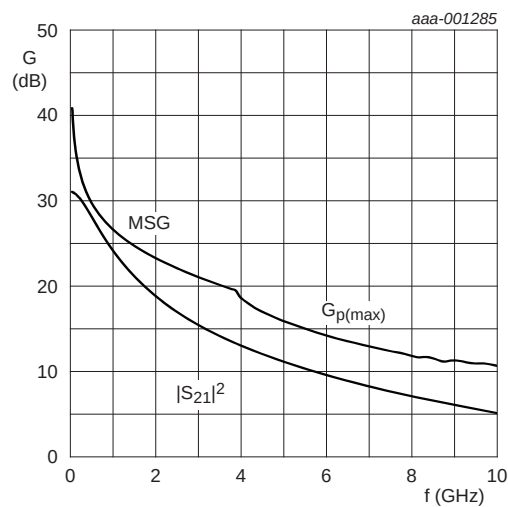
Fig 6. Transition frequency as a function of collector current; typical values



$V_{CE} = 3.5\text{ V}$ ;  $T_{amb} = 25\text{ }^{\circ}\text{C}$ .

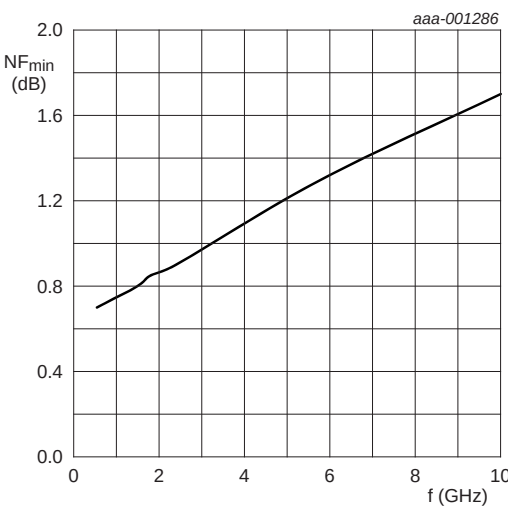
- (1)  $f = 5.8\text{ GHz}$
- (2)  $f = 10.0\text{ GHz}$

Fig 7. Gain as a function of collector current; typical value



$V_{CE} = 3.5\text{ V}$ ;  $I_C = 15\text{ mA}$ ;  $T_{amb} = 25\text{ }^{\circ}\text{C}$ .

Fig 8. Gain as a function of frequency; typical values

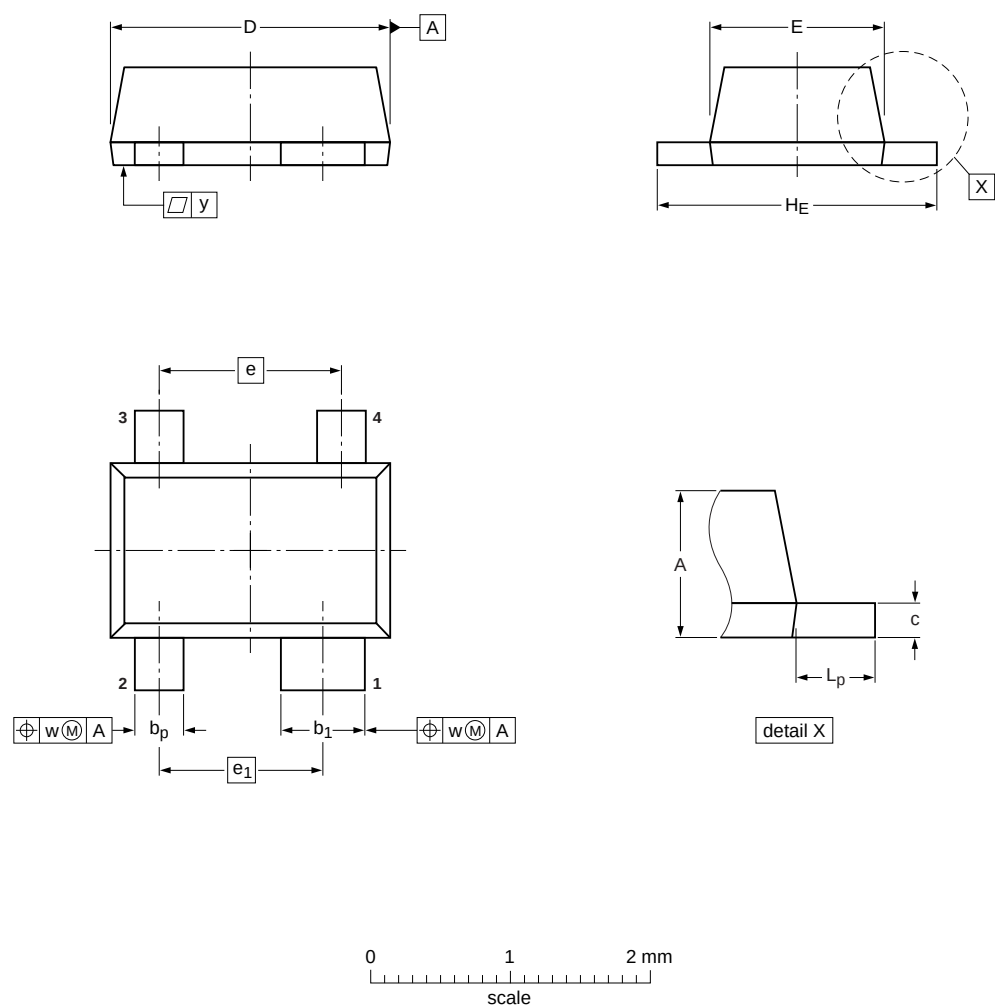


$V_{CE} = 3.5\text{ V}$ ;  $I_C = 15\text{ mA}$ ;  $T_{amb} = 25\text{ }^{\circ}\text{C}$ .

Fig 9. Minimum noise figure as a function of frequency; typical values

9. Package outline

Plastic surface-mounted flat pack package; reverse pinning; 4 leadsSOT343F



DIMENSIONS (mm are the original dimensions)

| UNIT | A <sub>max</sub> | b <sub>p</sub> | b <sub>1</sub> | c            | D          | E            | e   | e <sub>1</sub> | H <sub>E</sub> | L <sub>p</sub> | w   | y   |
|------|------------------|----------------|----------------|--------------|------------|--------------|-----|----------------|----------------|----------------|-----|-----|
| mm   | 0.75<br>0.65     | 0.4<br>0.3     | 0.7<br>0.5     | 0.25<br>0.10 | 2.2<br>1.8 | 1.35<br>1.15 | 1.3 | 1.15           | 2.2<br>2.0     | 0.48<br>0.38   | 0.2 | 0.1 |

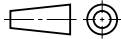
| OUTLINE<br>VERSION | REFERENCES |       |       |  | EUROPEAN<br>PROJECTION                                                                | ISSUE DATE           |
|--------------------|------------|-------|-------|--|---------------------------------------------------------------------------------------|----------------------|
|                    | IEC        | JEDEC | JEITA |  |                                                                                       |                      |
| SOT343F            |            |       |       |  |  | 05-07-12<br>06-03-16 |

Fig 10. Package outline SOT343F

## 10. Abbreviations

Table 8. Abbreviations

| Acronym | Description                     |
|---------|---------------------------------|
| DC      | Direct Current                  |
| DRO     | Dielectric Resonator Oscillator |
| Ku      | Kurtz under                     |
| LNA     | Low Noise Amplifier             |
| LNB     | Low Noise Block                 |
| NPN     | Negative-Positive-Negative      |
| RF      | Radio Frequency                 |

## 11. Revision history

Table 9. Revision history

| Document ID    | Release date                                                                                                                                                                                                                                      | Data sheet status  | Change notice | Supersedes  |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|---------------|-------------|
| BFU668F v.3    | 20120124                                                                                                                                                                                                                                          | Product data sheet | -             | BFU668F v.2 |
| Modifications: | <ul style="list-style-type: none"><li>• <a href="#">Table 1 on page 2</a>: maximum value for <math>h_{FE}</math> has been changed.</li><li>• <a href="#">Table 7 on page 5</a>: maximum value for <math>h_{FE}</math> has been changed.</li></ul> |                    |               |             |
| BFU668F v.2    | 20120120                                                                                                                                                                                                                                          | Product data sheet | -             | BFU668F v.1 |
| BFU668F v.1    | 20111108                                                                                                                                                                                                                                          | Product data sheet | -             | -           |

## 12. Legal information

### 12.1 Data sheet status

| Document status <sup>[1][2]</sup> | Product status <sup>[3]</sup> | Definition                                                                            |
|-----------------------------------|-------------------------------|---------------------------------------------------------------------------------------|
| Objective [short] data sheet      | Development                   | This document contains data from the objective specification for product development. |
| Preliminary [short] data sheet    | Qualification                 | This document contains data from the preliminary specification.                       |
| Product [short] data sheet        | Production                    | This document contains the product specification.                                     |

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL <http://www.nxp.com>.

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## 14. Contents

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|           |                                                                 |           |
|-----------|-----------------------------------------------------------------|-----------|
| <b>1</b>  | <b>Product profile</b> . . . . .                                | <b>1</b>  |
| 1.1       | General description . . . . .                                   | 1         |
| 1.2       | Features and benefits . . . . .                                 | 1         |
| 1.3       | Applications . . . . .                                          | 1         |
| 1.4       | Quick reference data . . . . .                                  | 2         |
| <b>2</b>  | <b>Pinning information</b> . . . . .                            | <b>2</b>  |
| <b>3</b>  | <b>Ordering information</b> . . . . .                           | <b>3</b>  |
| <b>4</b>  | <b>Marking</b> . . . . .                                        | <b>3</b>  |
| <b>5</b>  | <b>Limiting values</b> . . . . .                                | <b>3</b>  |
| <b>6</b>  | <b>Thermal characteristics</b> . . . . .                        | <b>3</b>  |
| <b>7</b>  | <b>Characteristics</b> . . . . .                                | <b>5</b>  |
| <b>8</b>  | <b>Application information</b> . . . . .                        | <b>6</b>  |
| 8.1       | BFU668F Ku-band Dielectric Resonator Oscillator (DRO) . . . . . | 6         |
| 8.2       | Graphs . . . . .                                                | 7         |
| <b>9</b>  | <b>Package outline</b> . . . . .                                | <b>10</b> |
| <b>10</b> | <b>Abbreviations</b> . . . . .                                  | <b>11</b> |
| <b>11</b> | <b>Revision history</b> . . . . .                               | <b>11</b> |
| <b>12</b> | <b>Legal information</b> . . . . .                              | <b>12</b> |
| 12.1      | Data sheet status . . . . .                                     | 12        |
| 12.2      | Definitions . . . . .                                           | 12        |
| 12.3      | Disclaimers . . . . .                                           | 12        |
| 12.4      | Trademarks . . . . .                                            | 13        |
| <b>13</b> | <b>Contact information</b> . . . . .                            | <b>13</b> |
| <b>14</b> | <b>Contents</b> . . . . .                                       | <b>14</b> |

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