BFP760

High Gain and High Linearity Low Noise Amplifier for 2.4 GHz WLAN

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RF and Protection Devices
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1 About Wireless Fidelity (Wi-Fi®) / Wireless LAN (WLAN)

Wireless Fidelity (Wi-Fi®) or well-known as wireless LAN (WLAN) plays a major role in today’s communications by enabling constant connection in the 2.4 GHz and broadband Internet access for users with laptops or devices equipped with wireless network interface while roaming within the range of fixed access points (AP) or a public hotspot. Different applications like home entertainment with wireless high-quality multimedia signal transmission, home networking notebooks, mass data storages and printers implement 2.4 GHz into their system for wireless connectivity. For this kind of high-speed high data rate wireless communication standards it is essential to ensure the quality of the link path. Major performance criteria of these equipments have to be fulfilled: sensitivity, strong signal capability and interference immunity. Below a general application diagram of a WLAN system is shown.

![Figure 1](image)

**Figure 1** 2.4 GHz Wi-Fi® Wireless LAN (WLAN, IEEE802.11b/g/n/a/c/ac) Front-End

In order to increase the system sensitivity, an excellent low noise amplifier (LNA) in front of the receiver is mandatory, especially in an environment with very weak signal strength and because of the insertion loss of the single-pole-double-throw (SPDT) switch and the Bandpass Filter (BPF) or diplexer. The typical allowed receiver chain Noise Figure (NF) of approx. 2 dB can only be achieved by using a high-gain low noise amplifier (LNA).
In addition, strong signal environment can exist when the equipment is next to a transmitter. In that case, the LNA must be linear enough, i.e. have high 1dB compression point. This avoids saturation, degradation of the gain and increased noise figure.

This application note is focusing on the LNA block, but Infineon does also support with RF-switches, TVS-diodes for ESD protection and RF Schottky diodes for power detection.
2 BFP760 Overview

2.1 Features

- Very low noise amplifier based on Infineon’s reliable, high volume SiGe:C technology.
- High linearity $OIP_3 = 27$ dBm @ 5.5 GHz, 3 V, 30 mA.
- High transition frequency $f_T = 45$ GHz @ 1 GHz, 3 V, 35 mA.
- $N_{F_{\text{min}}} = 0.95$ dB @ 5.5 GHz, 3 V, 10 mA.
- Transducer gain $|S_{21}|^2 = 16$ dB @ 3.5 GHz, 3 V, 10 mA.
- Low power consumption, ideal for mobile applications.
- Easy to use Pb-free (RoHS compliant) and halogen-free standard package with visible leads.
- Qualification report according to AEC-Q101 available.

![BFP760 in SOT343](image)

2.2 Key Applications of BFP760

- As Low Noise Amplifier (LNA) in
  - Mobile and fixed connectivity applications: WLAN 802.11a/b/c/g/n, WiMAX 2.5/3.5 GHz, 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
  - UMTS/LTE mobile phone applications
  - ISM applications like RKE, AMR and Zigbee, as well as for emerging wireless applications

- As discrete active mixer, buffer amplifier in VCOs
2.3 Description

The BFP760 is a linear low noise wideband NPN bipolar RF transistor. The device is based on Infineon’s reliable high volume silicon germanium carbon (SiGe:C) heterojunction bipolar technology. The collector design supports voltages up to $V_{CEO} = 4.0 \text{ V}$ and currents up to $I_C = 70 \text{ mA}$. With its high linearity at currents as low as 10 mA the device supports energy efficient designs. The typical transit frequency is approximately 45 GHz. The device is housed in an easy to use plastic SOT-343 package with visible leads.

![Figure 3 Package and pin definitions of BFP760](image)

**Table 1 Pin Assignment of BFP760**

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Symbol</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>B</td>
<td>Transistor base</td>
</tr>
<tr>
<td>2</td>
<td>E</td>
<td>Transistor emitter</td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>Transistor collector</td>
</tr>
<tr>
<td>4</td>
<td>E</td>
<td>Transistor emitter</td>
</tr>
</tbody>
</table>
3 Application Circuit and Performance Overview

Device: BFP760  
Application: High Gain and High Linearity Low Noise Amplifier for 2.4 GHz WLAN  
PCB Marking: M130125 V1.4e

3.1 Summary of Measurement Results

Table 2 Electrical Characteristics (at room temperature)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
<th>Comment/Test Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Range</td>
<td>Freq</td>
<td>2.4-2.5 GHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DC Voltage</td>
<td>Vcc</td>
<td>3.0 V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DC Current</td>
<td>Icc</td>
<td>14.5 mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gain (on mode)</td>
<td>G_{on}</td>
<td>16.7 dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gain (off mode)</td>
<td>G_{off}</td>
<td>-16.3 dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noise Figure</td>
<td>NF</td>
<td>0.92 dB</td>
<td></td>
<td>SMA and PCB losses (~0.06 dB) are subtracted</td>
</tr>
<tr>
<td>Input Return Loss</td>
<td>RL_{in}</td>
<td>13 dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Return Loss</td>
<td>RL_{out}</td>
<td>13 dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reverse Isolation</td>
<td>I_{Rev}</td>
<td>24.2 dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input P1dB (On mode)</td>
<td>IP1dB_{on}</td>
<td>-9.7 dBm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input P1dB (Off mode)</td>
<td>IP1dB_{off}</td>
<td>&gt;10 dBm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output P1dB (On mode)</td>
<td>OP1dB_{on}</td>
<td>7 dBm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input IP3</td>
<td>IIP3</td>
<td>-0.2 dBm</td>
<td></td>
<td>Power @ Input: -30 dBm (f_1 = 2440) MHz, (f_2 = 2441) MHz</td>
</tr>
<tr>
<td>Output IP3</td>
<td>OIP3</td>
<td>16.5 dBm</td>
<td></td>
<td>Power @ Input: -30 dBm (f_1 = 2440) MHz, (f_2 = 2441) MHz</td>
</tr>
<tr>
<td>Stability</td>
<td>k</td>
<td>(\geq 1.0)</td>
<td></td>
<td>Stability measured from 10MHz to 15GHz</td>
</tr>
</tbody>
</table>
3.2 BFP760 as Low Noise Amplifier for 2.4 GHz WLAN

This application note presents the high gain low noise amplifier using BFP760 for 2.4 GHz WLAN applications.

The circuit requires only nine 0402 passive components. It has in band gain of 16.7dB. The circuit achieves an input and output return loss more than 12 dB. The noise figure is about 0.92 dB (SMA and PCB losses are subtracted) for the whole frequency band. Furthermore, the circuit is unconditionally stable till 15 GHz. At 2440 MHz, using two tones spacing of 1 MHz, the output third order intercept point OIP3 reaches 16.5 dBm. Input 1dB compression point IP1dB of -9.7 dBm. The off mode gain is about -16 dB. The input P1dB compression in the off-mode for the whole frequency range is more than 10 dBm.
3.3 Schematics and Bill-of-Materials

A proper RF grounding is required to ensure the LNA performance. Please refer to Chapter 5 for the layout proposal.

PCB = M100511 0.4 mm EDG BFP760
PCB Board Material = FR4
Layer spacing (top RF to internal ground plane): 0.2 mm

Figure 4 Schematics of the BFP760 Application Circuit

Table 3 Bill-of-Materials

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
<th>Size</th>
<th>Manufacturer</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>1.8</td>
<td>pF</td>
<td>0402</td>
<td>Various</td>
<td>Input DC block &amp; input matching</td>
</tr>
<tr>
<td>C2</td>
<td>39</td>
<td>pF</td>
<td>0402</td>
<td>Various</td>
<td>RF decoupling / blocking cap</td>
</tr>
<tr>
<td>C3</td>
<td>1.8</td>
<td>pF</td>
<td>0402</td>
<td>Various</td>
<td>Output DC block &amp; output matching</td>
</tr>
<tr>
<td>L1</td>
<td>2</td>
<td>nH</td>
<td>0402</td>
<td>Murata LQG series</td>
<td>Input matching</td>
</tr>
<tr>
<td>L2</td>
<td>2.7</td>
<td>nH</td>
<td>0402</td>
<td>Murata LQG series</td>
<td>Output matching</td>
</tr>
<tr>
<td>R1</td>
<td>33</td>
<td>kΩ</td>
<td>0402</td>
<td>Various</td>
<td>DC biasing</td>
</tr>
<tr>
<td>R2</td>
<td>82</td>
<td>Ω</td>
<td>0402</td>
<td>Various</td>
<td>Stability improvement</td>
</tr>
<tr>
<td>R3</td>
<td>30</td>
<td>Ω</td>
<td>0402</td>
<td>Various</td>
<td>DC biasing (provides DC negative feedback to stabilize DC operating point over temperature variation, transistor $h_{FE}$ variation, etc.)</td>
</tr>
<tr>
<td>R4</td>
<td>2.2</td>
<td>Ω</td>
<td>0402</td>
<td>Various</td>
<td>Stability improvement and output matching</td>
</tr>
<tr>
<td>R4</td>
<td>18</td>
<td>kΩ</td>
<td>0402</td>
<td>Various</td>
<td>Bypass mode DC biasing</td>
</tr>
<tr>
<td>Q1</td>
<td></td>
<td></td>
<td>SOT343</td>
<td>Infineon Technologies</td>
<td>BFP760 SiGe: C Heterojunction Bipolar RF Transistor</td>
</tr>
</tbody>
</table>
4 Measurement Graphs

Figure 5  Insertion Power Gain of the 2.4 GHz WLAN LNA with BFP760

Figure 6  Wideband Insertion Power Gain of the 2.4 GHz WLAN LNA with BFP760
Figure 7  Noise Figure of BFP760 LNA for 2.4 - 2.5 GHz

Figure 8  Reverse Isolation of the 2.4 GHz WLAN LNA with BFP760
Figure 9  Input Matching of the 2.4 GHz WLAN LNA with BFP760

Figure 10  Input Matching of 2.4 GHz WLAN LNA with BFP760 (Smith Chart)
Figure 11  Output Matching of the 2.4 GHz WLAN LNA with BFP760

Figure 12  Output Matching of the 2.4 GHz WLAN LNA with BFP760 (Smith Chart)
Figure 13  Wideband Stability k Factor of the 2.4 GHz WLAN LNA with BFP760

Figure 14  Wideband Stability Mu Factor of the 2.4 GHz WLAN LNA with BFP760
Figure 15  Input 1dB Compression Point of the BFP760 Circuit

Figure 16  Output 3rd Order Intercept Point of BFP760 at 2440 MHz
Figure 17  Off mode Insertion Power Gain of the 2.4 GHz WLAN LNA with BFP760

Figure 18  Off mode input 1dB compression point of the 2.4 GHz WLAN LNA with BFP760
5 Evaluation Board and Layout Information

In this application note, the following PCB is used:

- PCB Marking: M130125 V1.4e
- PCB material: FR4
- $\varepsilon_r$ of PCB material: 4.3 (FR4)

Figure 19  Photo Picture of Evaluation Board (overview) <PCB Marking Myymmdd Rev. x.x>

Figure 20  Photo Picture of Evaluation Board (detailed view)
Figure 21  Layout Proposal for RF Grounding of the 2.4 GHz WLAN LNA with BFP760

Figure 22  PCB Layer Information

Copper 35μm  Vias
FR4 Core, 0.2mm  FR4 Prepreg, 0.8mm
6 Authors

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