BFR840L3RHESD

Low Noise Amplifier for 2.4 GHz - 2.5 GHz Wireless LAN Application

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Other Trademarks

Last Trademarks Update 2011-11-11
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1 Introduction

1.1 Wi-Fi

Wireless-Fidelity (Wi-Fi) is a registered trademark made of the Wi-Fi Alliance created to certify devices for wireless LAN (WLAN) applications based on the IEEE 802.11 standard. The Wi-Fi function is one of the most important connectivity functions in notebooks, smartphones, and tablet PCs. The WLAN standard has evolved over the years from its legacy systems known as 802.11-1997, through 802.11a, b, g, and n, to the newest 802.11ac. Today, the trend is rapidly changing where Wi-Fi is not only used for high data rate access to the internet but also for content consumption such as streaming music and High Definition video on TVs, smart phones, tablets, game consoles etc.

In the 2.4 GHz frequency band, the 802.11b/g/n wireless LAN devices suffer from interference from other devices operating in this ISM band, such as wireless keyboards or Bluetooth devices. In order 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.

A general application diagram of 2.4 GHz wireless LAN system is shown in Figure 1.

![General block diagram 2.4 GHz Wi-Fi Wireless LAN and WiMAX Front-End](image_url)

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 SPDT switch and the Bandpass Filter (BPF) or diplexer.
The typical allowed receiver chain Noise Figure (NF) of approximately 2 dB can only be achieved by using a high-gain LNA.

This application note represents the results of Low Noise Amplifier for the 2.4 GHz to 2.5 GHz Wireless LAN application using BFR840L3RHESD. It achieves a NF level of approx. 1.3 dB, and the gain ranges from 20 dB to 21 dB over this frequency band. The circuit achieves an input return loss of approx. 15 dB and output return loss of 12 dB. The circuit requires 9 passive 0201 SMD components, and it is unconditionally stable from 10 MHz to 10 GHz.

At 2450 MHz, using two tones spacing of 1 MHz, the Output Third Order Intercept Point (OIP3) reaches +13.5 dBm. Besides, we obtain Input 1 dB Compression Point (IP1dB) of -18.6 dBm at 2450 MHz.

This application note focuses on the LNA block, but Infineon also supports RF-switches, TVS-diodes for ESD protection and RF_Schottky_diodes for power detection for this application.
2 Device description

The BFR840L3RHESD is a low noise SiGe:C HBT transistor. It provides inherently good input and output power match as well as noise match. Without lossy external matching components at the input leads to a low external parts count, to a very good noise figure and to a very high transducer gain in the 2.4 GHz and 5 GHz WLAN application. Integrated protection elements at in- and output make the device robust against ESD and excessive RF input power. The device offers its high performance at low current and voltage and is especially well-suited for portable battery powered applications. The BFR840L3RHESD is housed in low-height 0.31mm TSLP-3-9 package specially fitting into modules. Further variants are available in industry standard visible-leads SOT343 package (BFP840ESD) and in flat-leads TSFP-4-1 package (BFP840FESD).

2.1 Features

- Based on Infineon’s reliable, high volume SiGe:C technology
- High end RF performance and robustness:
  - 20 dBm maximum RF input power, 1.5 kV HBM ESD hardness
- Transition frequency $f_T = 75$ GHz enables best in class noise performance at high frequencies:
  - $NF_{\text{min}} = 0.65$ dB at 5.5 GHz, 1.1 dB at 12 GHz, 1.8 V, 5 mA
- High gain $|S21|^2 = 19$ dB at 5.5 GHz, 1.8 V, 10 mA
- Ideal for low voltage applications e.g. $V_{\text{CC}} = 1.2$ V and 1.8 V (2.85 V, 3.3 V, 3.6 V requires corresponding collector resistor)
- Low power consumption, ideal for mobile applications
- Easy to use Pb free (RoHS compliant) and halogen free industry standard package with visible leads

2.2 Key Applications

The BFR840L3RHESD’s key applications include Low Noise Amplifier (LNA) in

- Mobile and fixed connectivity applications: WLAN 802.11, WiMAX and UWB
- Satellite communication systems: satellite radio (SDARs, DAB), navigation systems and C-band LNB (1st and 2nd stage LNA)
- Ku-band LNB front-end (2nd stage or 3rd stage LNA and active mixer)
- Ka-band oscillators (DROs)
3 Application Circuit

3.1 Schematic Diagram

All passives are “0201” case size
Inductors → LQP30T Series
Capacitors → GRM Series

A proper RF grounding is required to ensure the LNA performance. Please refer to Figure 17 for the layout proposal.

Total Component Count = 10
including BFR840L3RHESD transistor
Inductors = 2 (Low Q)
Resistors = 3
Capacitors = 4

PCB = M120510 BFR840L3RHESD
PCB Board Material = Standard FR4
Layer spacing (top RF to internal ground plane): 0.2 mm

Figure 2 Application circuit of 2.4 GHz – 2.5 GHz WLAN LNA with BFR840L3RHESD
### 3.2 Bill of Materials

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
<th>Package</th>
<th>Manufacturer</th>
<th>Comment</th>
</tr>
</thead>
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<tr>
<td>C1</td>
<td>1.2</td>
<td>pF</td>
<td>0201</td>
<td>Murata GRM0335 series</td>
<td>Input matching and DC blocking</td>
</tr>
<tr>
<td>C2</td>
<td>22</td>
<td>pF</td>
<td>0201</td>
<td>Murata GRM0335 series</td>
<td>Output DC blocking</td>
</tr>
<tr>
<td>C3</td>
<td>33</td>
<td>pF</td>
<td>0201</td>
<td>Murata GRM0335 series</td>
<td>RF decoupling</td>
</tr>
<tr>
<td>C4</td>
<td>33</td>
<td>pF</td>
<td>0201</td>
<td>Murata GRM0335 series</td>
<td>RF decoupling</td>
</tr>
<tr>
<td>R1</td>
<td>33</td>
<td>kΩ</td>
<td>0201</td>
<td>Various</td>
<td>DC biasing</td>
</tr>
<tr>
<td>R2</td>
<td>15</td>
<td>Ω</td>
<td>0201</td>
<td>Various</td>
<td>Output matching and stability improvement</td>
</tr>
<tr>
<td>R3</td>
<td>120</td>
<td>Ω</td>
<td>0201</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>L1</td>
<td>2.2</td>
<td>nH</td>
<td>0201</td>
<td>Murata LQP30T</td>
<td>Input matching</td>
</tr>
<tr>
<td>L2</td>
<td>1.8</td>
<td>nH</td>
<td>0201</td>
<td>Murata LQP30T</td>
<td>Output matching</td>
</tr>
<tr>
<td>Q1</td>
<td>BFR840L3RHESD</td>
<td></td>
<td></td>
<td>Infineon Technologies</td>
<td>SiGe:C Heterojunction Bipolar RF Transistor</td>
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</table>
4 Performance Overview

Device: BFR840L3RHESD
Application: Low Noise Amplifier for 2.4 - 2.5 GHz Wireless LAN with BFR840L3RHESD using 0201 SMDs

PCB Marking: BFR840L3RHESD TSLP-3-9 M120510

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>
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</thead>
<tbody>
<tr>
<td>DC Voltage</td>
<td>Vcc</td>
<td>3.0</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>DC Current</td>
<td>Icc</td>
<td>9.0</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>Frequency Range</td>
<td>Freq</td>
<td>2400</td>
<td>2500</td>
<td>MHz</td>
</tr>
<tr>
<td>Gain</td>
<td>G</td>
<td>20.8</td>
<td>20.5</td>
<td>dB</td>
</tr>
<tr>
<td>Noise Figure</td>
<td>NF</td>
<td>1.38</td>
<td>1.26</td>
<td>dB, PCB and SMA connector losses of 0.1 dB subtracted</td>
</tr>
<tr>
<td>Input Return Loss</td>
<td>RLin</td>
<td>16.3</td>
<td>15.1</td>
<td>dB</td>
</tr>
<tr>
<td>Output Return Loss</td>
<td>RLout</td>
<td>12.2</td>
<td>13.5</td>
<td>dB</td>
</tr>
<tr>
<td>Reverse Isolation</td>
<td>RRev</td>
<td>26.5</td>
<td>26.3</td>
<td>dB</td>
</tr>
<tr>
<td>Input P1dB</td>
<td>IP1dB</td>
<td>-18.6</td>
<td>dBm</td>
<td>f = 2450 MHz</td>
</tr>
<tr>
<td>Output P1dB</td>
<td>OP1dB</td>
<td>+1.1</td>
<td>dBm</td>
<td>f = 2450 MHz</td>
</tr>
<tr>
<td>Input IP3</td>
<td>IIP3</td>
<td>-7.2</td>
<td>dBm</td>
<td>f₁ = 2450 MHz, f₂ = 2451 MHz, Pin = -30 dBm each tone</td>
</tr>
<tr>
<td>Output IP3</td>
<td>OIP3</td>
<td>13.5</td>
<td>dBm</td>
<td>f₁ = 2450 MHz, f₂ = 2451 MHz, Pin = -30 dBm each tone</td>
</tr>
<tr>
<td>Stability</td>
<td>k</td>
<td>&gt; 1</td>
<td>--</td>
<td>Unconditionally stable from 10 MHz to 10 GHz</td>
</tr>
</tbody>
</table>
5 Measured Graphs

Figure 3 Narrowband Insertion Power Gain of 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD

Figure 4 Wideband Insertion Power Gain of 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD
**Figure 5**  Input Matching of 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD

**Figure 6**  Input Matching of 2.4 GHz – 2.5 GHz WLAN LNA with BFR840L3RHESD in Smith Chart
Figure 7  Output Matching of 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD

Figure 8  Output Matching of 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD in Smith Chart
**Figure 9**  
Reverse Isolation of 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD

**Figure 10**  
Noise Figure of 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD
BFR840L3RHESD
Low Noise Amplifier for 2.4 GHz - 2.5 GHz WLAN Application

Measured Graphs

Figure 11  Input 1 dB Compression Point of 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD

Figure 12  Output Third Order Interpoint of 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD
Figure 13  Stability factor $k$ of 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD

Figure 14  Stability factor $\mu_1$ and $\mu_2$ of 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD
6 Evaluation Board

Figure 15 Picture of the populated board 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD (M120510)

Figure 16 Zoom in picture of the populated board 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD
Figure 17  Layout Proposal for RF Grounding of the 2.4-2.5 GHz WLAN LNA with BFR840L3RHESD

Figure 18  PCB layer stack
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