BFP843

BFP843 SiGe:C Ultra Low Noise RF Transistor in Dual-Band 2.4 - 2.5 GHz & 5 - 6 GHz WiFi / WLAN Application

(For 802.11a / b / g / n / ac Wireless LAN Applications)
Table of Content

1 Introduction .......................................................................................................................... 5
  1.1 About Wi-Fi®/Wireless LAN (WLAN) ........................................................................... 5

2 BFP843 Overview .................................................................................................................. 7
  2.1 Features .......................................................................................................................... 7
  2.2 Key Applications of BFP843 ......................................................................................... 7

3 BFP843 as Dual-Band LNA for 2.4 – 2.5 and 5.0 – 6.0 GHz Wireless LAN Applications .... 8
  3.1 Description ...................................................................................................................... 8
  3.2 Performance Overview ................................................................................................. 9
  3.3 Schematics and Bill-of-Materials .................................................................................. 10

4 Measurement Graphs .......................................................................................................... 11

5 Evaluation Board and Layout Information .......................................................................... 19

6 Authors ................................................................................................................................ 21

List of Figures

Figure 1 Dual-Band Wi-Fi® Wireless LAN at 2.4 - 2.5 GHz and 5 - 6 GHz ................................. 6
Figure 2 BFP843 in SOT343 .................................................................................................. 7
Figure 3 Package and pin connections of BFP843 in Topview .................................................. 8
Figure 4 Schematic Diagram of the Application Circuit ............................................................ 10
Figure 5 Wideband Insertion Power Gain of the 2.4 – 2.5 GHz & 5 – 6 GHz WLAN LNA with BFP843 .................................................................................................................. 11
Figure 6 Reverse Isolation of the 2.4 – 2.5 GHz & 5 – 6 GHz WLAN LNA with BFP843 ........ 11
Figure 7 Noise Figure of BFP843 for 2.4 – 2.5 GHz ............................................................... 12
Figure 8 Noise Figure of BFP843 for 5 – 6 GHz ..................................................................... 12
Figure 9 Input Matching of the 2.4 – 2.5 GHz & 5 – 6 GHz WLAN LNA with BFP843 ........... 13
Figure 10 Input Matching of the 2.4 – 2.5 GHz & 5 – 6 GHz WLAN LNA with BFP843 (Smith Chart) .......................................................................................................................... 13
Figure 11 Output Matching of the 2.4 – 2.5 GHz & 5 – 6 GHz WLAN LNA with BFP843 ..... 14
Figure 12 Output Matching of the 2.4 – 2.5 GHz & 5 – 6 GHz WLAN LNA with BFP843 (Smith Chart) .......................................................................................................................... 14
Figure 13 Plot of Broadband Stability k Factor ........................................................................ 15
Figure 14 Plot of Broadband Stability μ Factor ......................................................................... 15
Figure 15 Input 1dB Compression Point of BFP843 Dual-Band WLAN LNA at 2400 MHz .... 16
Figure 16 Input 1dB Compression Point of BFP843 Dual-Band WLAN LNA at 5500 MHz .... 16
Figure 17 Output 3rd Order Intercept Point of Dual-Band WLAN LNA with BFP843 (at 2.4 GHz) .......................................................................................................................... 17
Figure 18 Output 3rd Order Intercept Point of Dual-Band WLAN LNA with BFP843 (at 5.5 GHz) .......................................................................................................................... 17
Figure 19 OFF-Mode (Vcc = 0V, Icc = 0mA) S21 of Dual-Band WLAN LNA with BFP843 .... 18
Figure 20 Photo Picture of Evaluation Board of Dual-Band WLAN LNA with BFP843 .............. 19
Figure 21 Zoom-In of Photo Picture ....................................................................................... 19
Figure 22 Layout Proposal for RF Grounding of the 2.4 – 6 GHz WLAN LNA with BFP843 .... 20
Figure 23 PCB Layer Information ......................................................................................... 20

List of Tables

Table 1 Summary of Measurement Results ............................................................................. 9
Table 2 Bill-of-Materials ......................................................................................................... 10
1 Introduction

1.1 About Wi-Fi®/Wireless LAN (WLAN)

The Wi-Fi® function is one of the most important connectivity functions in notebooks, smart phones and tablet PCs. 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 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 internet but also for content consumption such as streaming music and High Definition video on TVs, smart phones, tablets, game consoles etc.

With the requirements on wireless data quality becoming more stringent than ever, the new Wireless LAN standards are being developed by using higher order modulation schemes, wider channels and multiple data streams.

Wi-Fi according to IEEE802.11b/g/n at 2.4 GHz widely implemented over years suffers from interference from other devices such as cordless phones, microwave ovens, Bluetooth devices etc. in the 2.4 GHz space. 802.11a/n operating at 5 GHz has less interference and can transmit data at greater speeds (54 Mbps) but at the cost of reduced range. 802.11n provides enhanced performance and range over prior 802.11 technologies by operating in both the 2.4 GHz and 5 GHz. It adds two significant technologies: MIMO (Multiple input-Multiple output) and 40 MHz channels. With this, data rates up to 600Mbps (for 4 streams) can be achieved in the 5GHz band. To cater to these high throughput requirements, major performance criteria have to be fulfilled: sensitivity, strong signal capability and interference immunity.

The Figure 1 shows one example of general block diagram of a dual band WLAN system.
A Wi-Fi router has to receive relatively weak signals from Wi-Fi enabled devices such as mobile phones. Therefore, it should have high sensitivity to detect a weak signal in the presence of strong interfering signals. We can improve the sensitivity of the receiver by using a low noise amplifier (LNA) as a first block of the receiver front end to improve the signal-to-noise ratio (SNR) of the overall system. As an example, an increase in the sensitivity by 5 dB corresponds to nearly double link distance.

WLAN systems are subject to co-channel interference and also interference from strong co-existing cellular signals. High linearity characteristics such as 3rd-order intercept point (IP3) and 1dB compression point (P1dB) are required to improve an application's ability to distinguish between desired signals and spurious signals received close together. 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 for WLAN.
2 BFP843 Overview

2.1 Features

- Low noise broadband NPN RF transistor based on Infineon’s reliable, high volume SiGe:C bipolar technology
- High maximum RF input power and ESD robustness
- Unique combination of high RF performance, robustness and ease of use
- Low noise figure: $N_{F_{\text{min}}} = 1.0 \, \text{dB at 2.4 GHz and 1.2 dB at 5.5 GHz}$, $1.8 \, \text{V, 8 mA}$
- High gain $|S_{21}|^2 = 21.5 \, \text{dB at 2.4 GHz and 15.5 dB at 5.5 GHz}$, $1.8 \, \text{V, 15 mA}$
- $OIP_3 = 23 \, \text{dBm at 2.4 GHz and 20 dBm at 5.5 GHz}$, $1.8 \, \text{V, 15 mA}$
- Ideal for low voltage applications e.g. $V_{\text{CC}} = 1.2 \, \text{V}$ and $1.8 \, \text{V (2.85 V, 3.3 V, 3.6 V requires corresponding collector resistor)}$
- Low power consumption, ideal for mobile applications
- Thin small flat Pb-free (RoHS compliant) and halogen-free package
- Qualification report according to AEC-Q101 available

2.2 Key Applications of BFP843

As Low Noise Amplifier (LNA) in:

- Wireless Communications: 2.4GHz Wireless LAN IEEE802.11b/g/n, 5-6 GHz Wireless LAN IEEE802.11a/n/ac, WiMAX
- Satellite navigation systems (e.g. GPS, GLONASS, COMPASS...) and satellite C-band LNB (1st and 2nd stage LNA)
- Broadband amplifiers: Dualband WLAN, multiband mobile phone, UWB up to 10 GHz
- ISM bands up to 10 GHz
3 BFP843 as Dual-Band LNA for 2.4 – 2.5 and 5.0 – 6.0 GHz Wireless LAN Applications

3.1 Description

BFP843 is a discrete SiGe:C hetero-junction bipolar transistor (HBT) specifically designed for high performance dual band 2-6 GHz band low noise amplifier (LNA) solutions for Wi-Fi connectivity applications. This has been developed using Infineon’s latest B9HFM technology. The key features of this technology are very high transition frequency \( f_T = 80 \) GHz and low parasitics, which enable to achieve higher gain and lower noise figure compared to the previous generation RF transistor BFR740L3RH. BFP843 features an integrated on-chip R-C feedback network. The negative feedback reduces the effects of performance variations of the amplifier. The design is therefore less sensitive to variations in PCB layout resulting in an amplifier with broader bandwidth, easier impedance matching and improved stability margin. However the price paid for using negative feedback is slight degradation of noise figure and decrease in gain.

The BFP843 is housed in low-height 1.1mm SOT343 package specially fitting into modules. It is also available in other packages, e.g. BFR843EL3 in TSLP-3-9 and BFP843F in TSFP-4-1 package.

The BFP843 has an integrated 1.5 kV HBM ESD protection which makes the device robust against electrostatic discharge and extreme RF input power. The device offers its high performance at low current and voltage and is especially well-suited for portable battery powered applications in which energy efficiency is a key requirement.

Figure 3 shows the pin assignment of package of BFP843 in the top view:
3.2 Performance Overview

Device: BFP843
Application: Dual-Band LNA for 2.4 - 6.0 GHz WLAN Applications
PCB Marking: BFP843 SOT343 M130130
(designed for 0402 SMD)

Table 1 Summary of Measurement Results

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
<th>Note/Test Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC Voltage</td>
<td>$V_{CC}$</td>
<td>3.0</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>DC Current</td>
<td>$I_{CC}$</td>
<td>13.8</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>Frequency Range</td>
<td>Freq</td>
<td>2400 2500 5100 5500 5900</td>
<td>MHz</td>
<td></td>
</tr>
<tr>
<td>Gain (On Mode)</td>
<td>$G_{ON}$</td>
<td>19.6 19.4 15.3 14.7 14.2</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>Gain (Off Mode)</td>
<td>$G_{OFF}$</td>
<td>-21.6 -21.7 -27.3 -31.6 -41.5</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>Noise Figure</td>
<td>NF</td>
<td>1.06 1.08 1.34 1.36 1.35</td>
<td>dB</td>
<td>SMA and PCB losses (0.05 dB @ 2.4 GHz, 0.1 dB @ 5 GHz) are subtracted</td>
</tr>
<tr>
<td>Input Return Loss</td>
<td>$R_{L_{in}}$</td>
<td>12.0 12.1 25.0 21.4 16.7</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>Output Return Loss</td>
<td>$R_{L_{out}}$</td>
<td>18.1 17.5 28.4 21.0 15.8</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>Reverse Isolation</td>
<td>$I_{Rev}$</td>
<td>27.5 27.6 25.8 25.0 24.3</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>Input P1dB (On Mode)</td>
<td>$I_{P1dB_{ON}}$</td>
<td>-12.3 -12.5 -8.4 -8.4 -7.4</td>
<td>dBm</td>
<td></td>
</tr>
<tr>
<td>Output P1dB (On Mode)</td>
<td>$O_{P1dB_{ON}}$</td>
<td>6.3 5.9 5.9 5.3 5.8</td>
<td>dBm</td>
<td></td>
</tr>
<tr>
<td>Input IP3</td>
<td>$I_{IP3}$</td>
<td>-2.1 -3.0 1.4 1.3 1.3</td>
<td>dBm</td>
<td>Power @ Input: -25 dBm</td>
</tr>
<tr>
<td>Output IP3</td>
<td>$O_{IP3}$</td>
<td>17.6 17.0 16.7 16.1 15.2</td>
<td>dBm</td>
<td>Stability measured from 10MHz to 15GHz</td>
</tr>
<tr>
<td>Stability</td>
<td>k</td>
<td>&gt; 1</td>
<td></td>
<td>--</td>
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3.3 Schematics and Bill-of-Materials

![Schematic Diagram of the Application Circuit](image)

**Figure 4** Schematic Diagram of the Application Circuit

**Table 2** 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>6.8</td>
<td>pF</td>
<td>0402</td>
<td>Various</td>
<td>Input DC block</td>
</tr>
<tr>
<td>C2</td>
<td>6.8</td>
<td>pF</td>
<td>0402</td>
<td>Various</td>
<td>Output DC block</td>
</tr>
<tr>
<td>C3</td>
<td>33</td>
<td>pF</td>
<td>0402</td>
<td>Various</td>
<td>RF decoupling / blocking cap</td>
</tr>
<tr>
<td>L1</td>
<td>5.1</td>
<td>nH</td>
<td>0402</td>
<td>LQG</td>
<td>RF decoupling / Output matching</td>
</tr>
<tr>
<td>R1</td>
<td>100</td>
<td>Ω</td>
<td>0402</td>
<td>Various</td>
<td>DC biasing</td>
</tr>
<tr>
<td>R2</td>
<td>15</td>
<td>kΩ</td>
<td>0402</td>
<td>Various</td>
<td>DC biasing</td>
</tr>
<tr>
<td>R3</td>
<td>0</td>
<td>Ω</td>
<td>0402</td>
<td>Various</td>
<td>Jumper</td>
</tr>
<tr>
<td>Q1</td>
<td></td>
<td></td>
<td></td>
<td>SOT343</td>
<td>BFP843 SiGe:C Heterojunction Bipolar RF Transistor</td>
</tr>
</tbody>
</table>

All passives are “0402” case size
Inductors: LQG
Capacitors: various

Inductors = 1 (LQG)
Resistors = 3
Capacitors = 3

PCB = BFP843 SOT343 M130130
Layer spacing (top RF to internal ground plane): 0.2 mm
4 Measurement Graphs

**Figure 5** Wideband Insertion Power Gain of the 2.4 – 2.5 GHz & 5 – 6 GHz WLAN LNA with BFP843

**Figure 6** Reverse Isolation of the 2.4 – 2.5 GHz & 5 – 6 GHz WLAN LNA with BFP843
Figure 7  Noise Figure of BFP843 for 2.4 – 2.5 GHz

Figure 8  Noise Figure of BFP843 for 5 – 6 GHz
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5 Evaluation Board and Layout Information

Figure 20  Photo Picture of Evaluation Board of Dual-Band WLAN LNA with BFP843

Figure 21  Zoom-In of Photo Picture
Figure 22  Layout Proposal for RF Grounding of the 2.4 – 6 GHz WLAN LNA with BFP843

Figure 23  PCB Layer Information
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