Driver Amplifier: BFP780

Driver Amplifier for LTE Band-41 (2.6 GHz) Applications

About this document

Scope and purpose

This application note describes Infineon’s Driver Amplifier: BFP780 as 2.6 GHz Driver Application for LTE Band-41 applications.

1. Application circuit for LTE Band-41 application covers frequency range of 2.6 GHz
2. The BFP780 as Driver Amplifier can be used for:
   - Cellular, PCS, DCS, UMTS, LTE, CDMA, WCDMA, GSM, GPRS
   - WLAN, WiMAX, WLL and MMDS
   - ISM, AMR
   - UHF television, CATV, DBS
3. High linearity driver or pre-driver in the transmit chain.
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1 Introduction

1.1 Overview of LTE-Advanced Small Cell Base Stations

Mobile communication technologies have seen tremendous growth in recent years. In order to satisfy the rising demand of the next level of wireless data capacity, small cells, which are fully featured, short range mobile phone base stations, are gathering more and more focus to increase wireless network capacity and reduce network costs.

The main capacity enhancement of small cells is the result from aggressive frequency re-use. Meanwhile, small cells are placed much closer to the mobile device users, especially for the indoor applications. Due to the small cells installed indoor, the heavy signal losses across the walls of buildings between indoor user and outdoor LTE macrocell network can be avoided. Data rates increase with the improved signal strength and signal quality. The uplink power from the mobile devices also decreases at the same time, which extends the mobile device battery lifetime. Compared to leased lines for macrocell network backhaul, the public internet can be served as small cells backhaul to decrease the backhaul costs. Meanwhile, small cells are much more flexible to be installed and more easily deployed than a typical macro base station, providing cost savings for operators.

Small cell family comprises femtocells, picocells, and microcells, depending on the variety of capacity and power ranges. Table 1 lists the small cell family classification.

<table>
<thead>
<tr>
<th>Small Cell Category</th>
<th>Output Average Power (dBm)</th>
<th>Maximum Cell Radius (m)</th>
<th>Wireless Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femtocell</td>
<td>10–13</td>
<td>10</td>
<td>3G/4G/WiFi</td>
</tr>
<tr>
<td>Picocell</td>
<td>24–30</td>
<td>200</td>
<td>3G/4G</td>
</tr>
<tr>
<td>Microcell</td>
<td>30–37</td>
<td>2000</td>
<td>2G/3G/4G</td>
</tr>
</tbody>
</table>

The small cell can be divided into two distinct function blocks: the RF front-end and the baseband processor. The block diagram is presented in Figure 1. The RF front-end converts the baseband data into a RF radiated signal in the transmit circuit, and vice versa in the receive chain.
Infineon Technologies is the leading company with a broad portfolio of RF product solutions including driver amplifiers, low noise amplifiers (LNAs), switches, ESD protection diodes and GNSS module for mobile phone as well as for small cell base transceiver station (BTS) applications.

1.2 Infineon Driver Amplifier Family

The driver amplifier, also known as gain block, is an important functional block in RF transceiver systems requiring high output power. The Power Amplifier (PA), the final stage of a signal amplifier chain, requires a certain input power level to operate in the linear mode, which usually cannot be delivered by the transceiver IC directly. In these cases, external one or two stage driver amplifiers are required. Driver amplifiers are generally operated in linear class-A mode to enable high linearity and high gain, thereby keeping spurious signals generated by the PA low, by reducing intermodulation products. Class-A amplifiers are also the right choice for broadband operation at low power levels.

BFQ790 and BFP780 are described as general purpose medium power transistor in Infineon’s Silicon Germanium (SiGe) product portfolio for wireless infrastructure applications. These include mobile basestation transceivers, cellular repeaters, ISM band amplifiers and
test equipment. Their operating frequency range can be as high as 3.6 GHz, and the application circuit can be optimized for specific frequency bands with external matching components.

The BFQ790 is a single stage driver amplifier with very high linearity. Its output 1dB compression point is 27 dBm. The device is housed in the halogen-free industry standard package SOT89. The high thermal conductivity of silicon substrate and the low thermal resistance of the package add up to a thermal resistance of only 35 K/W, which leads to moderate junction temperatures even at high dissipated power values. The proper die attach with good thermal contact is 100% tested, so that there is minimum variation of thermal properties. The device is based on Infineon's reliable and cost effective NPN SiGe technology running in high volume. The collector design allows safe operation with 5 V supply voltage. The BFQ790 is very rugged. A special collector design prevents from thermal runaway respectively 2nd breakdown, which leads to a high ruggedness against mismatch at the output. The special design of the emitter/base diode makes it robust and yields to a high maximum RF input power capability.

The BFP780 is a single stage driver amplifier with high linearity and high power gain. Its output 1dB compression point is above 22 dBm. The chip is housed in a halogen-free industry standard package SOT343. The proper die attach with good thermal contact is 100% tested and verified. Same as BFQ790, the device is based on Infineon's reliable and cost effective NPN SiGe technology running in high volume. The collector design allows safe operation with 5 V supply voltage. For further information about BFP780 please refer its datasheet and application.

In this application note, the driver application circuit of BFP780 for LTE Band-41 (2.6 GHz) and its measurement results are presented. The BFP780 driver provides 14.4 dB gain in the frequency of 2.6 GHz. The output 1dB compression point (OP1dB) is 22 dBm measured at 2.6 GHz. Besides, in two-tone test with tone spacing of 1 MHz, the output third order intercept point (OIP3) reaches 34.7 dBm and the carrier to the 3rd IM product ratio (CIMR3) is larger than 47 dBc when the signal power per tone reaches 10 dBm.
BFP780 Overview

1.3 Features

- High 3rd order intercept point OIP3 of 34 dBm @ 2700 MHz, 5 V, 65 mA (measured in testfixture, 37 dBm in application)
- High compression point OP1dB of 22.5 dBm @ 2700 MHz, 5 V, 80 mA, corresponding to 43% collector efficiency
- High maximum power gain Gmax=18.5 dB @ 2700 MHz, 5 V, 80 mA
- Low noise figure of 0.85 dB @ 900 MHz, 5 V, 20 mA
- Single stage, intended for external matching
- Very rugged: Worst case output mismatch VSWR 10:1
- High maximum RF input power PRFinmax of 20 dBm
- Safe operation with single 5 V supply
- 100% test of proper die attach for reproducible thermal contact
- 100% DC and RF tested
- Easy to use large signal compact (VBIC) model available
- Cost effective NPN SiGe technology running in very high volume
- Easy to use Pb-free (RoHS compliant) and halogen-free industry standard package SOT343, low RthJS of 35 K/W

Figure 2  BFP780 in SOT343

1.4 Key Applications of BFP780

As
- High linearity driver or pre-driver in the transmit chain
- 2nd or 3rd stage LNA in the receive chain
- IF or LO buffer amplifier
In
- Commercial / industrial wireless infrastructure / basestations
- Repeaters
- Automated test equipment
For
- Cellular, PCS, DCS, UMTS, LTE, CDMA, WCDMA, GSM, GPRS
- WLAN, WiMAX, WLL and MMDS
- ISM, AMR
- UHF television, CATV, DBS

Attention: ESD (Electrostatic discharge) sensitive device, observe handling precautions
BFP780 Driver Amplifier Application Circuit for LTE Band-41 (2.6 GHz) Applications

1.5 Performance Overview

Device: BFP780
Application: Driver Amplifier for LTE Band-41 (2.6 GHz) Applications
PCB Marking: M140116-SOT343

Table 2 Summary of Measurement Results

<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>DC Voltage</td>
<td>V&lt;sub&gt;CC&lt;/sub&gt;</td>
<td>5.0</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Quiescent DC Current</td>
<td>I&lt;sub&gt;Cq&lt;/sub&gt;</td>
<td>80</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>Frequency Range</td>
<td>F&lt;sub&gt;req&lt;/sub&gt;</td>
<td>2.6</td>
<td>GHz</td>
<td></td>
</tr>
<tr>
<td>Gain</td>
<td>G</td>
<td>14.4</td>
<td>dB</td>
<td>V&lt;sub&gt;cc&lt;/sub&gt; = 5.0 V, I&lt;sub&gt;cc&lt;/sub&gt; = 80 mA, the PCB and SMA losses are not substracted.</td>
</tr>
<tr>
<td>Input Return Loss</td>
<td>R&lt;sub&gt;Lin&lt;/sub&gt;</td>
<td>13</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>Output Return Loss</td>
<td>R&lt;sub&gt;Out&lt;/sub&gt;</td>
<td>11</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>Reverse Isolation</td>
<td>I&lt;sub&gt;Rev&lt;/sub&gt;</td>
<td>22</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>Output P1dB</td>
<td>O&lt;sub&gt;1dB&lt;/sub&gt;</td>
<td>22</td>
<td>dBm</td>
<td>Measured at 2.6 GHz</td>
</tr>
<tr>
<td>Output IP3</td>
<td>O&lt;sub&gt;IP3&lt;/sub&gt;</td>
<td>34.7</td>
<td>dBm</td>
<td>Power @ output: 10 dBm per tone f&lt;sub&gt;1&lt;/sub&gt;=2600 MHz, f&lt;sub&gt;2&lt;/sub&gt;=2601 MHz</td>
</tr>
<tr>
<td>Stability</td>
<td>µ1, µ2</td>
<td>&gt; 1</td>
<td>--</td>
<td>Measured up to 10 GHz</td>
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Note: Please refer to Chapter 2 for corresponding graphs
1.6 Schematics and Bill-of-Materials

**Figure 3** Schematics of the BFP780 Application Circuit for LTE Band-41 (2.6 GHz)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
<th>Size</th>
<th>Manufacturer</th>
<th>Comment</th>
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<tr>
<td>Q1</td>
<td>BFP780</td>
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<td>SOT343</td>
<td>Infineon</td>
<td>SiGe driver transistor</td>
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<tr>
<td>C1</td>
<td>1</td>
<td>pF</td>
<td>0402</td>
<td>Murata GRM</td>
<td>Input matching and DC blocking</td>
</tr>
<tr>
<td>C2</td>
<td>0.5</td>
<td>pF</td>
<td>0402</td>
<td>Murata GRM</td>
<td>Input matching</td>
</tr>
<tr>
<td>C3</td>
<td>12</td>
<td>pF</td>
<td>0201</td>
<td>Murata GRM</td>
<td>Stability</td>
</tr>
<tr>
<td>C4</td>
<td>1.5</td>
<td>pF</td>
<td>0402</td>
<td>Murata GRM</td>
<td>Output matching and DC blocking</td>
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<tr>
<td>C5</td>
<td>10</td>
<td>nF</td>
<td>0402</td>
<td>Murata GRM</td>
<td>RF bypass</td>
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<tr>
<td>C6</td>
<td>10</td>
<td>pF</td>
<td>0402</td>
<td>Murata GRM</td>
<td>RF bypass</td>
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<tr>
<td>C7</td>
<td>100</td>
<td>pF</td>
<td>0402</td>
<td>Murata GRM</td>
<td></td>
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<tr>
<td>C8</td>
<td>0.5</td>
<td>pF</td>
<td>0402</td>
<td>Murata GRM</td>
<td>Output matching</td>
</tr>
<tr>
<td>L1</td>
<td>18</td>
<td>nH</td>
<td>0402</td>
<td>Murata LQG series</td>
<td>RF choke and output matching</td>
</tr>
<tr>
<td>L2</td>
<td>1.6</td>
<td>nH</td>
<td>0402</td>
<td>Murata LQG series</td>
<td>Output matching</td>
</tr>
<tr>
<td>R1</td>
<td>6.5</td>
<td>kΩ</td>
<td>0402</td>
<td>Murata Various</td>
<td>DC biasing</td>
</tr>
<tr>
<td>R2</td>
<td>33</td>
<td>Ω</td>
<td>0201</td>
<td>Murata Various</td>
<td>Stability</td>
</tr>
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2 Measurement Graphs

Figure 4 Wideband Insertion Power Gain of the BFP780 for Band-41 Applications

Figure 5 Narrowband Insertion Power Gain of the BFP780 for Band-41 Applications
Figure 6  Input Matching of the BFP780 for Band-41 Applications

Figure 7  Input Matching (Smith Chart) of the BFP780 for Band-41 Applications
Figure 8  Output Matching of the BFP780 for Band-41 Applications

Figure 9  Output Matching (Smith Chart) of the BFP780 for Band-41 Applications
Figure 10  Reverse Isolation of the BFP780 for Band-41 Applications

Figure 11  Output 1dB Compression Point of the BFP780 for Band-41 Applications
Figure 12  Carrier to IM3 Ratio of the BFP780 for Band-41 Applications

Figure 13  DC Current Consumption versus Output Power of the BFP780 for Band-41 Applications
Figure 14 Stability Mu1, Mu2-factors of the BFP780 for Band-41 Applications
Evaluation Board and Layout Information

In this application note, the following PCB is used:

PCB Marking: M140116-SOT343
PCB material: FR4
\( \varepsilon_r \) of PCB material: 4.6
3 Authors

Dr. Olim Hidayov, RF Application Engineer of Business Unit “RF and Sensing Protection Devices”
4 Remark

The graphs are generated with the simulation program AWR Microwave Office®.
## Revision History

Major changes since the last revision

<table>
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<th>Page or Reference</th>
<th>Description of change</th>
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