# AN11449
Low Noise Flat Gain 40M~1GHz DVB-C LNA with BFG425W

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## Document information

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<td>Keywords</td>
<td>BFG425W, 40M~1GHz LNA, DVB-C,</td>
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<td>Abstract</td>
<td>This document provides circuit simulation, schematic, layout, BOM and typical EVB performance for a 40M ~ 1GHz DVB-C LNA</td>
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### Revision history

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1. Introduction

With the new NXP silicon bipolar double poly BFG400W series, it is possible to design low noise amplifiers for high frequency applications with a low current and a low supply voltage. These amplifiers are well suited for the new generation low voltage high frequency wireless applications.

In this note a first study of such an amplifier will be given. This amplifier is designed for a wideband working frequency from 40MHz to 1GHz. It is designed for DVB-C application, so the solution need provide a pretty good Gain flatness.

DVB-C stands for "Digital Video Broadcasting - Cable" and it is the DVB European consortium standard for the broadcast transmission of digital television over cable. This system transmits a MPEG-2 or MPEG-4 family digital audio/digital video stream, using a QAM modulation with channel coding. The standard was first published by the ETSI in 1994, and subsequently became the most widely used transmission system for digital cable television in Europe. It is deployed worldwide in systems ranging from the larger cable television networks (CATV) down to smaller satellite master antenna TV (SMATV) systems.

Key Benefits:

• High transition frequency
• Wideband applications, e.g. analog and digital cellular telephones, cordless telephones (PHS, DECT, etc.)
• Lowest current consumption meaning greener products
• SOT343F package for high performance and easy manufacturing

![Fig 1. BFG425W 40M ~ 1GHz DVB-C LNA EVB Demo Board](image-url)
2. Requirements and design of the 40M ~ 1GHz DVB-C LNA

The circuit shown in this application note is intended to demonstrate the performance of the BFG425W in a 40M ~ 1GHz LNA for DVB-C applications.

Key requirements for this application are:

- Frequency Band 40M – 1GHz
- Gain
- Input/output Match
- Linearity
- NF
- Gain Flatness

3. Design and Simulation

The 40M ~ 1GHz DVB-C LNA consists of one stage BFG425W amplifier.

The design has been simulated, and the simulation results are given in the following figures.

The LNA shows excellent match at input/output with greater than 9.0dB return loss from 40MHz to 1GHz and wideband gain around 13.3dB, with good +/-1.1dB gain flatness between whole 960MHz frequency band. Customer also could tune the value of attenuator resistors at output of Demo, to reach the Gain level they want.

In addition, the LNA provide Noise Figure performance below 2.8dB in whole frequency band. With only 18mA it also shows a high input IP2 level of 14dBm @400MHz, as well as high input IP3 of 5.5dBm @400MHz.

Due to frequency limitation of 75-to-50 ohm adaptor, we can't measure K-factor to high frequency band, but simulation result gives out the LNA is unconditionally stable at 10MHz-10GHz.

3.1 BFG425W 40M ~ 1GHz DVB-C LNA Simulation
Fig 2. BFG425W 40M ~ 1GHz DVB-C LNA Simulation: Circuit (Capacitors GRM1555 & Inductors LQG15)
3.2 BFG425W 40M ~ 1GHz DVB-C LNA Simulation Results

3.2.1 Gain and Match in 40M ~ 1GHz Band

Fig 3. BFG425W 40M ~ 1GHz DVB-C LNA Simulation: Gain and Match
3.2.2 Noise Figure in 40M ~ 1GHz Band

![Graph showing noise figure for BFG425W in the 40M ~ 1GHz band.]

**Fig 4.** BFG425W 40M ~ 1GHz DVB-C LNA Simulation: Noise Figure

- **m8**: freq = 40.00MHz, nf(2) = 2.694
- **m9**: freq = 1.000GHz, nf(2) = 2.775
3.2.3 Stability

Fig 5. BFG425W 40M ~ 1GHz DVB-C LNA Simulation: Stability

4. Application Board

The 40M ~ 1GHz DVB-C LNA evaluation board simplifies the evaluation of the BFG425W application. The evaluation board enables testing of the device performance and requires no additional support circuitry. The board is fully assembled with the BFG425W transistor, including input and output matching components, to optimize performance.

The board is supplied with two F connectors at input and output, in order to keep same performance in real STB (set top box). Please make it clear, in this Demo micro-stripe line and F connector are all design for 75ohm.

4.1 Application Circuit Schematic
4.2 Application Board Bill-Of-Material

Table 1. BFG425W 40M ~ 1GHz DVB-C LNA Part List
Customer can choose their preferred vendor but should be aware that the performance could be affected.

<table>
<thead>
<tr>
<th>Item</th>
<th>Reference (Fig 7)</th>
<th>Type</th>
<th>Vendor</th>
<th>Value</th>
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<tbody>
<tr>
<td>1</td>
<td>C1, C2, C4</td>
<td>GRM1555C1</td>
<td>Murata</td>
<td>10nF</td>
</tr>
<tr>
<td>2</td>
<td>C3</td>
<td>GRM1555C1</td>
<td>Murata</td>
<td>33pF</td>
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<tr>
<td>3</td>
<td>C5</td>
<td>GRM1555C1</td>
<td>Murata</td>
<td>100nF</td>
</tr>
<tr>
<td>4</td>
<td>L1</td>
<td>LQG15</td>
<td>Murata</td>
<td>15nH</td>
</tr>
<tr>
<td>5</td>
<td>L2</td>
<td>chip ferrite bead</td>
<td>Murata</td>
<td>BLM18HE1S2SN1</td>
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<tr>
<td>6</td>
<td>R1</td>
<td></td>
<td></td>
<td>22R</td>
</tr>
<tr>
<td>7</td>
<td>R2</td>
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<td>680R</td>
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<tr>
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<td>R3</td>
<td></td>
<td></td>
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<td>7</td>
<td>R4, R5</td>
<td></td>
<td></td>
<td>4.3R</td>
</tr>
<tr>
<td>8</td>
<td>R6, R8</td>
<td></td>
<td></td>
<td>240R</td>
</tr>
<tr>
<td>11</td>
<td>R7</td>
<td></td>
<td></td>
<td>50R</td>
</tr>
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</table>
Typical Application Board Test Result

S-Parameter – Gain

![Graph showing S21 parameter for BFG425W from 40 MHz to 1 GHz]

Fig 7. BFG425W 40M ~ 1GHz DVB-C LNA: S-Parameter Gain
4.3.2 S-Parameter – Input Return Loss

![Graph showing S11 LogM 5.000dBV 0.00dB for BFG425W 40M~1GHz DVB-C LNA: S-Parameter Input Return Loss](image)

**Fig 8.** BFG425W 40M~1GHz DVB-C LNA: S-Parameter Input Return Loss
4.3.3 S-Parameter – Output Return Loss

Fig 9. BFG425W 40M ~ 1GHz DVB-C LNA: S-Parameter Output Return Loss
4.3.4 S-Parameter – Isolation

Fig 10. BFG425W 40M~1GHz DVB-C LNA: S-Parameter Isolation
4.3.5 Linearity/IP2

OIP2 = -21.9dBm + (65.7-22.6)dB + 5.7dB = 26.9dBm
IIP2 = 26.9dBm - 13.1dB = 13.8dBm

Note1, Input Power = -30dBm, f1 = 200MHz, f2 = 500MHz
Note2, 75-to-50 ohm adaptor Insertion Loss = 5.7dB
Note3, Gain @ 500MHz = 13.1dB

Fig 11. BFG425W 40M ~ 1GHz DVB-C LNA: IP2 @ f1=200MHz, f2=500MHz
OIP2 = -21.1dBm + (64.6-23.1)dB + 5.7dB = 26.1dBm
IIP2 = 26.1dBm - 12.6dB = 13.5dBm

Note1, Input Power = -30dBm, f1 = 100MHz, f2 = 800MHz
Note2, 75-to-50 ohm adaptor Insertion Loss = 5.7dB
Note3, Gain @ 800MHz = 12.6dB

Fig 12. BFG425W 40M ~ 1GHz DVB-C LNA: IP2 @ f1=100MHz, f2=800MHz
4.3.6 Linearity/IP3

OIP3 = 13.2dBm + 5.7dB = 18.9dBm
IIP3 = OIP3 - Gain = 18.9 - 13.9 = 5.0dBm

Note1, Two tones: f1: 80MHz, f2: 81MHz, -30dBm each tone, tone spacing: 1MHz
Note2, 75-to-50 ohm adaptor Insertion Loss = 5.7dB
Note3, Gain @ 80MHz = 13.9dB

Fig 13. BFG425W 40M ~ 1GHz DVB-C LNA: IP3 @ f1=80MHz, f1=81MHz
OIP3 = 12.7dBm+5.7dB = 18.4dBm
IIP3 = OIP3 - Gain = 18.9 -13.1 = 5.8dBm
Note1, Two tones: f1: 500MHz, f2: 501MHz, -30dBm each tone, tone spacing: 1MHz
Note2, 75-to-50 ohm adaptor Insertion Loss = 5.7dB
Note3, Gain @ 500MHz = 13.1dB

Fig 14. BFG425W 40M ~ 1GHz DVB-C LNA: IP3 @ f1=500MHz, f1=501MHz
OIP3 = 9.3dBm + 5.7dB = 15.0dBm
IIP3 = OIP3 - Gain = 15.0 - 12.3 = 2.7dBm
Note1, Two tones: f1: 900MHz, f2: 901MHz, -30dBm each tone, tone spacing: 1MHz
Note2, 75-to-50 ohm adaptor Insertion Loss = 5.7dB
Note3, Gain @ 900MHz = 12.3dB

**Fig 15. BFG425W 40M ~ 1GHz DVB-C LNA: IP3 @ f1=900MHz, f1=901MHz**

### 4.3.7 Noise Figure Measurement

The noise figure is measured under F-to-SMA adaptors connecting with the evaluation board, this 75-to-50ohm adaptor has 5.7dB insertion loss from 40MHz to 1GHz. The adaptor losses (RF_IN and RF_OUT loss = 5.7dB @ 40M~1GHz) of the connectors are subtracted.
4.3.8 Summary of the Typical Evaluation Board Test Result

Table 2. Typical results measured on the BFG425W 40M ~ 1GHz DVB-C LNA Evaluation Board

Operating frequency 40M ~ 1GHz, testing at 40MHz and 1GHz unless otherwise specified, Temp = 25°C.

All measurements are done with F-to-SMA adaptor connectors as reference plane.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>Vcc</td>
<td>3.0</td>
<td>V</td>
</tr>
<tr>
<td>Supply Current</td>
<td>Icc</td>
<td>18</td>
<td>mA</td>
</tr>
<tr>
<td>Noise Figure</td>
<td>@40MHz</td>
<td>NF</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>@520MHz</td>
<td>NF</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>@1GHz</td>
<td>NF</td>
<td>2.7</td>
</tr>
<tr>
<td>Power Gain</td>
<td>@40MHz</td>
<td>Gp</td>
<td>14.4</td>
</tr>
<tr>
<td></td>
<td>@1GHz</td>
<td>Gp</td>
<td>12.2</td>
</tr>
<tr>
<td>Gain Flatness</td>
<td>40M ~ 1GHz</td>
<td>Gf</td>
<td>+/- 1.1</td>
</tr>
<tr>
<td>Input Return Loss</td>
<td>@40MHz</td>
<td>IRL</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>@1GHz</td>
<td>IRL</td>
<td>9.0</td>
</tr>
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### Parameter Table

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<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Return Loss</td>
<td>@40MHz</td>
<td>ORL</td>
<td>23.9 dB</td>
</tr>
<tr>
<td></td>
<td>@1GHz</td>
<td>ORL</td>
<td>24.9 dB</td>
</tr>
<tr>
<td>Reverse Isolation</td>
<td>@40MHz</td>
<td>ISLrev</td>
<td>29.6 dB</td>
</tr>
<tr>
<td></td>
<td>@1GHz</td>
<td>ISLrev</td>
<td>27.3 dB</td>
</tr>
<tr>
<td>Input Second Order Intercept Point</td>
<td>f1: 200MHz, f2: 500MHz,</td>
<td>IIP2</td>
<td>13.8 dBm</td>
</tr>
<tr>
<td></td>
<td>f1: 100MHz, f2: 800MHz,</td>
<td>IIP2</td>
<td>13.5 dBm</td>
</tr>
<tr>
<td>Output Second Order Intercept Point</td>
<td>f1: 200MHz, f2: 500MHz,</td>
<td>OIP2</td>
<td>26.9 dBm</td>
</tr>
<tr>
<td></td>
<td>f1: 100MHz, f2: 800MHz,</td>
<td>OIP2</td>
<td>26.1 dBm</td>
</tr>
<tr>
<td>Input Third Order Intercept Point Two Tones:</td>
<td>f1: 80MHz, f2: 81MHz,</td>
<td>IIP3</td>
<td>5.0 dBm</td>
</tr>
<tr>
<td>Input power: -30dBm</td>
<td>f1: 500MHz, f2: 501MHz,</td>
<td>IIP3</td>
<td>5.8 dBm</td>
</tr>
<tr>
<td></td>
<td>f1: 900MHz, f2: 901MHz,</td>
<td>IIP3</td>
<td>2.7 dBm</td>
</tr>
<tr>
<td>Output Third Order Intercept Point Two Tones:</td>
<td>f1: 80MHz, f2: 81MHz,</td>
<td>OIP3</td>
<td>18.9 dBm</td>
</tr>
<tr>
<td>Input power: -30dBm</td>
<td>f1: 500MHz, f2: 501MHz,</td>
<td>OIP3</td>
<td>18.4 dBm</td>
</tr>
<tr>
<td></td>
<td>f1: 900MHz, f2: 901MHz,</td>
<td>OIP3</td>
<td>15.0 dBm</td>
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