WIDE BAND LOW NOISE AMPLIFIER GaAs MMIC

- GENERAL DESCRIPTION
  The NJG1145UA2 is a fully matched wide band low noise amplifier GaAs MMIC for terrestrial and satellite applications. To achieve wide dynamic range, the NJG1145UA2 offers high gain mode and low gain mode. Selecting high gain mode for weak signals, the NJG1145UA2 helps improve receiver sensitivity through high gain and low noise figure. Selecting low gain mode for strong signals, it bypasses LNA circuit to offer higher linearity. In high gain mode, the NJG1145UA2 achieves high gain and high IIP3 across the band. The ESD protection circuits are integrated into the MMIC. They achieve high ESD protection voltage. An ultra-small and ultra-thin package of EPFFP6-A2 is adopted.

- APPLICATION
  Terrestrial and Satellite applications from 90MHz to 2150MHz
  Digital TV, CATV, BS/CS and Set-top box
  LTE Router, modem and Base Station

- FEATURES
  - Wide operating frequency range 90MHz~2150MHz
  - Low voltage operation 2.8V typ.
  - External components count 3pcs. (capacitor: 2pcs, inductor: 1pc)
  - Small package size EPFFP6-A2 (package size: 1.0mmx1.0mmx0.37mm typ.)
  [High gain mode]
  - Current consumption 20mA typ.
  - High gain +15.0dB typ.
  - Low noise figure 1.5dB typ.
  [Low gain mode]
  - Low current consumption 11μA typ.
  - Gain(Low loss) -1.0dB typ.

- PIN CONFIGURATION

- TRUTH TABLE
  \[ H = V_{CTL(H)} \text{ and } L = V_{CTL(L)} \]
<table>
<thead>
<tr>
<th>( V_{CTL} )</th>
<th>LNA ON</th>
<th>Bypass</th>
<th>LNA mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>( H )</td>
<td>ON</td>
<td>OFF</td>
<td>High Gain mode</td>
</tr>
<tr>
<td>( L )</td>
<td>OFF</td>
<td>ON</td>
<td>Low Gain mode</td>
</tr>
</tbody>
</table>

Note: Specifications and description listed in this datasheet are subject to change without notice.
ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>CONDITIONS</th>
<th>RATINGS</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage</td>
<td>$V_{DD}$</td>
<td></td>
<td>5.0</td>
<td>V</td>
</tr>
<tr>
<td>Control voltage</td>
<td>$V_{CTL}$</td>
<td></td>
<td>5.0</td>
<td>V</td>
</tr>
<tr>
<td>Input power</td>
<td>$P_{IN}$</td>
<td>$V_{DD}=2.8V$</td>
<td>+15</td>
<td>dBm</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P_{D}$</td>
<td>4-layer FR4 PCB with through-hole (101.5x114.5mm), $T_{j}=150°C$</td>
<td>590</td>
<td>mW</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>$T_{opr}$</td>
<td></td>
<td>-40~+85</td>
<td>°C</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>$T_{stg}$</td>
<td></td>
<td>-55~+150</td>
<td>°C</td>
</tr>
</tbody>
</table>

ELECTRICAL CHARACTERISTICS1 (DC CHARACTERISTICS)

General conditions: $V_{DD}=2.8V$, $T_{a}=+25°C$, $Z_s=Z_l=50$ ohm

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>SYMBOL</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating voltage</td>
<td>$V_{DD}$</td>
<td></td>
<td>2.3</td>
<td>2.8</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td>Control voltage (High)</td>
<td>$V_{CTL(H)}$</td>
<td></td>
<td>1.3</td>
<td>1.8</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td>Control voltage (Low)</td>
<td>$V_{CTL(L)}$</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td>0.5</td>
<td>V</td>
</tr>
<tr>
<td>Operating current1</td>
<td>$I_{DD1}$</td>
<td>RF OFF, $V_{CTL}=1.8V$</td>
<td>-</td>
<td>20.0</td>
<td>27.0</td>
<td>mA</td>
</tr>
<tr>
<td>Operating current2</td>
<td>$I_{DD2}$</td>
<td>RF OFF, $V_{CTL}=0V$</td>
<td>-</td>
<td>11.0</td>
<td>25.0</td>
<td>μA</td>
</tr>
<tr>
<td>Control current</td>
<td>$I_{CTL}$</td>
<td>RF OFF, $V_{CTL}=1.8V$</td>
<td>-</td>
<td>6.0</td>
<td>10.0</td>
<td>μA</td>
</tr>
</tbody>
</table>
### ELECTRICAL CHARACTERISTICS

**Conditions:** freq=90~2150MHz, V_{DD}=2.8V, V_{CTRL}=1.8V, T_{A}=+25°C, Z_{s}=Z=50 ohm

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>SYMBOL</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small signal gain1</td>
<td>Gain1</td>
<td>Exclude PCB, connector losses*1</td>
<td>12.0</td>
<td>15.0</td>
<td>18.0</td>
<td>dB</td>
</tr>
<tr>
<td>Noise figure1</td>
<td>NF1</td>
<td>Exclude PCB, connector losses*2</td>
<td>-</td>
<td>1.5</td>
<td>2.3</td>
<td>dB</td>
</tr>
<tr>
<td>Input power 1dB gain compression</td>
<td>P_{-1dB(IN)}1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input 3rd order intercept point1</td>
<td>IIP3_1</td>
<td>f1=\text{freq}, f2=\text{freq}+100kHz, P_{IN}=\text{-26dBm}</td>
<td>+2.0</td>
<td>+10.0</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>2nd order IMD1</td>
<td>IM2_1</td>
<td>f1=200MHz, f2=500MHz, f_{meas}=700MHz, P_{IN1}=P_{IN2}=\text{-15dBm} *3</td>
<td>20.0</td>
<td>28.0</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>3rd order IMD1</td>
<td>IM3_1</td>
<td>f1=600MHz, f2=650MHz, f_{meas}=700MHz, P_{IN1}=P_{IN2}=\text{-15dBm} *3</td>
<td>35.0</td>
<td>45.0</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>Isolation</td>
<td>ISL</td>
<td>S12</td>
<td>-</td>
<td>-19.0</td>
<td>-15.0</td>
<td>dB</td>
</tr>
<tr>
<td>RF IN VSWR1</td>
<td>VSWRi1</td>
<td>-</td>
<td>2.2</td>
<td>3.2</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>RF OUT VSWR1</td>
<td>VSWRo1</td>
<td>-</td>
<td>1.5</td>
<td>2.2</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

*1 Input & output PCB and connector losses: 0.037dB(90MHz), 0.092dB(620MHz), 0.274dB(2150MHz)

*2 Input PCB and connector losses: 0.019dB(90MHz), 0.046dB(620MHz), 0.122dB(2150MHz)

*3 Definitions of IM2 and IM3.
**ELECTRICAL CHARACTERISTICS**

*(Low Gain mode)*

Conditions: \( \text{freq}=90\sim2150\text{MHz} \), \( V_{DD}=2.8\text{V} \), \( V_{CTL}=0\text{V} \), \( T_a=+25^\circ\text{C} \), \( Z_s=Z_l=50\text{ ohm} \)

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>SYMBOL</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small signal gain</td>
<td>Gain2</td>
<td>Exclude PCB, connector losses*1</td>
<td>-6.0</td>
<td>-1.0</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>Input power at 1dB gain compression</td>
<td>( P_{\text{1dB(IN)}} )</td>
<td>+10.0</td>
<td>+15.0</td>
<td>-</td>
<td>dBm</td>
<td></td>
</tr>
<tr>
<td>Input 3rd order intercept point</td>
<td>IIP3 _2</td>
<td>( f_1=\text{freq} ), ( f_2=\text{freq}+100\text{kHz} ), ( P_{\text{IN}}=-6\text{dBm} )</td>
<td>+20.0</td>
<td>+30.0</td>
<td>-</td>
<td>dBm</td>
</tr>
<tr>
<td>2nd order IMD</td>
<td>IMD2 _2</td>
<td>( f_1=200\text{MHz} ), ( f_2=500\text{MHz} ), ( f_{\text{meas}}=700\text{MHz} ), ( P_{\text{IN1}=P_{\text{IN2}}=-8\text{dBm} ) *3</td>
<td>55.0</td>
<td>66.0</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>3rd order IMD</td>
<td>IMD3 _2</td>
<td>( f_1=600\text{MHz} ), ( f_2=650\text{MHz} ), ( f_{\text{meas}}=700\text{MHz} ), ( P_{\text{IN1}=P_{\text{IN2}}=-8\text{dBm} ) *3</td>
<td>65.0</td>
<td>75.0</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>RF IN VSWR</td>
<td>VSWRI2</td>
<td>-</td>
<td>1.5</td>
<td>4.0</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>RF OUT VSWR</td>
<td>VSWRo2</td>
<td>-</td>
<td>1.5</td>
<td>4.0</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

*\(^{*1}\) Input & output PCB and connector losses: 0.037dB(90MHz), 0.092dB(620MHz), 0.274dB(2150MHz)*

*\(^{*3}\) Definitions of IM2 and IM3.*

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*Graphs showing IM2 and IM3 at different frequencies.*
### TERMINAL INFORMATION

<table>
<thead>
<tr>
<th>No.</th>
<th>SYMBOL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GND</td>
<td>Ground terminal. This terminal should be connected to the ground plane as close as possible for excellent RF performance.</td>
</tr>
<tr>
<td>2</td>
<td>GND</td>
<td>Ground terminal. This terminal should be connected to the ground plane as close as possible for excellent RF performance.</td>
</tr>
<tr>
<td>3</td>
<td>RFOUT</td>
<td>RF output terminal. This terminal doubles as the drain terminal of the LNA. Please connect this terminal to the power supply(VDD) via inductor(L1).</td>
</tr>
<tr>
<td>4</td>
<td>VCTL</td>
<td>Control voltage terminal.</td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
<td>Ground terminal. This terminal should be connected to the ground plane as close as possible for excellent RF performance.</td>
</tr>
<tr>
<td>6</td>
<td>RFIN</td>
<td>RF input terminal. This IC integrates an input DC blocking capacitor.</td>
</tr>
</tbody>
</table>
ELECTRICAL CHARACTERISTICS (High Gain mode)
Conditions: \( V_{DD}=2.8\, \text{V}, \quad V_{CTL}=1.8\, \text{V}, \quad Ta=25^\circ\, \text{C}, \quad Z_s=Z_l=50\, \text{ohm}, \) with application circuit
**ELECTRICAL CHARACTERISTICS** (High Gain mode)
Conditions: $V_{\text{CTL}}=1.8\text{V}$, $T_a=25^\circ\text{C}$, $Z_s=Z_l=50$ ohm, with application circuit
**ELECTRICAL CHARACTERISTICS** (High Gain mode)
Conditions: $V_{\text{CTL}}=1.8V$, $Ta=25^\circ\text{C}$, $Z_s=Z_l=50$ ohm, with application circuit

![Graph 1: ISL vs. VDD (f=620MHz)](image1)

![Graph 2: IDD vs. VDD (RF OFF)](image2)
**ELECTRICAL CHARACTERISTICS** (High Gain mode)
Conditions: \( V_{DD} = 2.8 \text{V}, V_{CTL} = 1.8 \text{V}, Z_s = Z_l = 50 \text{ohm} \), with application circuit

- **Gain, NF vs. Temperature**
  \( (f=620\text{MHz}) \)

- **P-1dB(IN) vs. Temperature**
  \( (f=620\text{MHz}) \)

- **OIP3, IIP3 vs. Temperature**
  \( (f_1=620\text{MHz}, f_2=f_1+100\text{kHz}, P_{in}=-26\text{dBm}) \)

- **IM2 vs. Temperature**
  \( (f_1=200\text{MHz}, f_2=500\text{MHz}, P_{in}=-15\text{dBm}) \)

- **IM3 vs. Temperature**
  \( (f_1=600\text{MHz}, f_2=650\text{MHz}, P_{in}=-15\text{dBm}) \)

- **VSWR vs. Temperature**
  \( (f=620\text{MHz}) \)
NJG1145UA2

**ELECTRICAL CHARACTERISTICS** (High Gain mode)
Conditions: $V_{DD}=2.8V$, $V_{CTL}=1.8V$, $Z_s=Z_l=50$ ohm, with application circuit

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**ISL vs. Temperature**

![Graph showing ISL vs. Temperature](image)

**I_{DD}, I_{CTL} vs. Temperature**

![Graph showing I_{DD}, I_{CTL} vs. Temperature](image)

**K factor vs. frequency**

![Graph showing K factor vs. frequency](image)
ELECTRICAL CHARACTERISTICS (High Gain mode)
Conditions: \( V_{DD} = 2.8 \text{V}, \ V_{CT} = 1.8 \text{V}, \ T_a = 25^\circ \text{C}, \ Z_s = Z_i = 50 \text{ ohm}, \) with application circuit
**ELECTRICAL CHARACTERISTICS** (Low Gain mode)
Conditions: $V_{DD}=2.8\text{V}$, $V_{CTL}=0\text{V}$, $T_a=25^\circ\text{C}$, $Z_s=Z_l=50\ \text{ohm}$, with application circuit
**ELECTRICAL CHARACTERISTICS** (Low Gain mode)

Conditions: \( V_{\text{CTL}} = 0 \text{V}, T_a = 25^\circ \text{C}, Z_s = Z_l = 50 \text{ ohm}, \) with application circuit
ELECTRICAL CHARACTERISTICS (Low Gain mode)
Conditions: $V_{\text{CTL}}=0\,\text{V}$, $T_a=25^\circ\text{C}$, $Z_s=Z_i=50\,\text{ohm}$, with application circuit
ELECTRICAL CHARACTERISTICS (Low Gain mode)
Conditions: $V_{DD}=2.8V$, $V_{ctl}=0V$, $Z_s=Z_i=50$ ohm, with application circuit
ELECTRICAL CHARACTERISTICS (Low Gain mode)

Conditions: \( V_{DD} = 2.8 \text{V}, \ V_{CTL} = 0 \text{V}, \ Z_s = Z_l = 50 \text{ ohm}, \) with application circuit

- **I\(_{DD}\) vs. Temperature** (RF OFF)
  - Temperature vs. \( I_{DD} \) (\( \mu \text{A} \))
  - Temperature range: \(-40^\circ \text{C} \) to \(+85^\circ \text{C}\)

- **K factor vs. frequency** (f=50MHz~20GHz)
  - Frequency vs. K factor
  - Temperature range: \(-40^\circ \text{C} \) to \(+85^\circ \text{C}\)

- **I\(_{DD}\) vs. V\(_{CTL}\)** (RF OFF)
  - V\(_{CTL}\) vs. \( I_{DD} \) (mA)
  - Temperature range: \(-40^\circ \text{C} \) to \(+85^\circ \text{C}\)
ELECTRICAL CHARACTERISTICS (Low Gain mode)
Conditions: $V_{DD}=2.8V$, $V_{CTL}=0V$, $T_a=25^\circ C$, $Z_s=Z_l=50$ ohm, with application circuit

- $S_{11}$, $S_{22}$ ($f=0.05GHz$ to $3GHz$)
- $S_{21}$, $S_{12}$ ($f=0.05GHz$ to $3GHz$)
- VSWR ($f=0.05GHz$ to $3GHz$)
- $Z_{in}$, $Z_{out}$ ($f=0.05GHz$ to $3GHz$)
- $S_{11}$, $S_{22}$ ($f=0.05GHz$ to $20GHz$)
- $S_{21}$, $S_{12}$ ($f=0.05GHz$ to $20GHz$)
**APPLICATION CIRCUIT**

(Top View)

- **C1**: Coupling and DC blocking capacitor at the output, and **C2**: Bypass capacitor.
- **L1**: RF choke. (DC feed inductor)
- In order not to couple with terminal **RFIN** and **RFOUT**, please layout ground pattern under the IC.
- All external parts are placed as close as possible to the IC.

**TEST PCB LAYOUT**

(Top View)

**PARTS LIST**

<table>
<thead>
<tr>
<th>Parts ID</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>TAIYO-YUDEN HK1005 Series</td>
</tr>
<tr>
<td>C1, C2</td>
<td>MURATA GRM03 Series</td>
</tr>
</tbody>
</table>

**PCB (FR-4):**
- \( t = 0.2 \text{mm} \)
- MICROSTRIP LINE WIDTH: \( 0.40 \text{mm} \) (\( Z_0 = 50 \text{ ohm} \))
- PCB SIZE: \( 14.0 \text{mm} \times 14.0 \text{mm} \)
### Measurement Block Diagram

**Measuring instruments**

- NF Analyzer : Agilent 8973A
- Noise Source : Agilent 346A

**Setting the NF analyzer**

**Measurement mode form**
- Device under test : Amplifier
- System downconverter : off

**Mode setup form**
- Sideband : LSB
- Averages : 16
- Average mode : Point
- Bandwidth : 4MHz
- Loss comp : off
- Tcold : setting the temperature of noise source (300.0K)

*Noise source and NF analyzer are connected directly.*

**Calibration Setup**

**Measurement Setup**

*Noise source and DUT, DUT and NF analyzer are connected directly.*
NJG1145UA2

■ PACKAGE OUTLINE (EPFFP6-A2)

Unit : mm
Substrate : FR-4
Terminal Treat : Au
Molding Material : Epoxy Resin
Weight : 0.855mg

Cautions on using this product
This product contains Gallium-Arsenide (GaAs) which is a harmful material.
- Do NOT eat or put into mouth.
- Do NOT dispose in fire or break up this product.
- Do NOT chemically make gas or powder with this product.
- To waste this product, please obey the relating law of your country.

(CAUTION)
The specifications on this databook are only given for information, without any guarantee as regards either mistakes or omissions. The application circuits in this databook are described only to show representative usages of the product and not intended for the guarantee or permission of any rights including the industrial rights.

This product may be damaged with electric static discharge (ESD) or spike voltage. Please handle with care to avoid these damages.