5 GHz Low Noise Amplifier with Bypass function

**FEATURES**
- Operating frequency $f = 4900$ to $5925$ MHz
- Operating voltage 2.5 to 5.5 V
  - [LNA active mode]
  - High gain 16 dB typ.
  - Low noise figure 0.95 dB typ.
  - High IIP3 +9 dBm typ.
- Small package size 1.6 x 1.6 x 0.397 mm$^3$ typ.
- RoHS compliant and Halogen Free, MSL1

**APPLICATION**
- LTE advanced in unlicensed spectrum (LTE-U/LAA)
- WLAN (IEEE 802.11 a/n/ac/ax)
- Small cell, CPE
- Access points, routers, gateways
- Wireless routers
- 5 GHz ISM radios

**GENERAL DESCRIPTION**
The NJG1175KG1 is a low noise amplifier for wireless receiver applications in the 4900 MHz to 5925 MHz. This LNA has a LNA pass-through function to select LNA active mode or bypass mode.
The NJG1175KG1 achieves High linearity, Low distortion, high gain, and low noise figure.
Integrated ESD protection device on each port achieves excellent ESD robustness.
The small and thin ESON6-G1 package is adopted.

**TRUTH TABLE**

<table>
<thead>
<tr>
<th>$V_{CTL}$</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>Bypass mode</td>
</tr>
<tr>
<td>H</td>
<td>LNA Active mode</td>
</tr>
</tbody>
</table>

**PIN CONFIGURATION**

<table>
<thead>
<tr>
<th>PIN NO.</th>
<th>SYMBOL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VCTL</td>
<td>Control signal input terminal</td>
</tr>
<tr>
<td>2</td>
<td>RFIN</td>
<td>RF input terminal</td>
</tr>
<tr>
<td>3</td>
<td>GND</td>
<td>Ground terminal</td>
</tr>
<tr>
<td>4</td>
<td>GND</td>
<td>Ground terminal</td>
</tr>
<tr>
<td>5</td>
<td>RFOUT</td>
<td>RF output terminal</td>
</tr>
<tr>
<td>6</td>
<td>VDD</td>
<td>Operating voltage supply terminal</td>
</tr>
</tbody>
</table>

Exposed pad: GND: Ground terminal
NJG1175KG1

■ PRODUCT NAME INFORMATION

NJG1175 KG1 (TE3)

Part Number Package Taping Form

■ ORDERING INFORMATION

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>PACKAGE OUTLINE</th>
<th>RoHS</th>
<th>HALOGEN-FREE</th>
<th>TERMINAL FINISH</th>
<th>MARKING</th>
<th>WEIGHT (mg)</th>
<th>MOQ (pcs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NJG1175KG1</td>
<td>ESON6-G1</td>
<td>Yes</td>
<td>Yes</td>
<td>Sn-Bi</td>
<td>1175</td>
<td>3.5</td>
<td>3,000</td>
</tr>
</tbody>
</table>

■ ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>RATINGS</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Input Power(1)</td>
<td>P_{IN}</td>
<td>+15</td>
<td>dBm</td>
</tr>
<tr>
<td>Supply Voltage(2)</td>
<td>V_{DD}</td>
<td>6.0</td>
<td>V</td>
</tr>
<tr>
<td>Control Voltage(3)</td>
<td>V_{CTL}</td>
<td>6.0</td>
<td>V</td>
</tr>
<tr>
<td>Power Dissipation(4)</td>
<td>P_{D}</td>
<td>1200</td>
<td>mW</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>T_{opr}</td>
<td>-40 to +105</td>
<td>°C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>T_{stag}</td>
<td>-55 to +150</td>
<td>°C</td>
</tr>
</tbody>
</table>

(1): V_{DD} = 3.3 V
(2): VDD port
(3): VCTL port
(4): Mounted on four-layer FR4 PCB with through-hole (101.5 × 114.3 mm), T_{j} = 150°C

■ POWER DISSIPATION VS. AMBIENT TEMPERATURE

Please, refer to the following Power Dissipation and Ambient Temperature.

(Please note the surface mount package has a small maximum rating of Power Dissipation [P_{D}], a special attention should be paid in designing of thermal radiation.)

Power Dissipation - Ambient Temperature Characteristic

Mounted on PCB

![Power Dissipation Graph](image)
**RECOMMENDED OPERATING CONDITIONS**

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>$V_{DD}$</td>
<td>2.5</td>
<td>3.3</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>Control Voltage (HIGH)</td>
<td>$V_{\text{CTL(H)}}$</td>
<td>1.3</td>
<td>3.3</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>Control Voltage (LOW)</td>
<td>$V_{\text{CTL(L)}}$</td>
<td>0</td>
<td>0</td>
<td>0.3</td>
<td>V</td>
</tr>
</tbody>
</table>

**ELECTRICAL CHARACTERISTICS 1 (DC CHARACTERISTICS)**

$T_a = 25^\circ\text{C}$, $Z_s = Z_l = 50$ Ω, with application circuit

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>TEST CONDITION</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Current 1</td>
<td>$I_{DD1}$</td>
<td>RF OFF, $V_{DD} = 3.3$ V, $V_{\text{CTL}} = 3.3$ V</td>
<td>-</td>
<td>13</td>
<td>18</td>
<td>mA</td>
</tr>
<tr>
<td>Operating Current 2</td>
<td>$I_{DD2}$</td>
<td>RF OFF, $V_{DD} = 3.3$ V, $V_{\text{CTL}} = 0$ V</td>
<td>-</td>
<td>20</td>
<td>100</td>
<td>μA</td>
</tr>
<tr>
<td>Control Current</td>
<td>$I_{\text{CTL}}$</td>
<td>RF OFF, $V_{\text{CTL}} = 3.3$ V</td>
<td>-</td>
<td>25</td>
<td>50</td>
<td>μA</td>
</tr>
</tbody>
</table>

**ELECTRICAL CHARACTERISTICS 2 (RF CHARACTERISTICS: LNA active mode)**

$f_{RF} = 4900$ to $5925$ MHz, $V_{DD} = 3.3$ V, $V_{\text{CTL}} = 3.3$ V, $T_a = 25^\circ\text{C}$, $Z_s = Z_l = 50$ Ω, with application circuit

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>TEST CONDITION</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small signal gain</td>
<td>Gain</td>
<td>Exclude PCB and connector losses $^1$</td>
<td>12</td>
<td>16</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>Noise figure</td>
<td>NF</td>
<td>Exclude PCB and connector losses $^2$</td>
<td>-</td>
<td>0.95</td>
<td>1.6</td>
<td>dB</td>
</tr>
<tr>
<td>Input power at 1 dB gain</td>
<td>$P_{1\text{dB(IN)}}$</td>
<td>$f_1 = f_{RF}, f_2 = f_{RF} + 1$ MHz, $P_{IN} = -30$ dBm</td>
<td>-14</td>
<td>-5</td>
<td>-</td>
<td>dBm</td>
</tr>
<tr>
<td>Input 3rd order intercept</td>
<td>$I_{\text{IP3_1}}$</td>
<td>$f_1 = f_{RF}, f_2 = f_{RF} + 1$ MHz, $P_{IN} = -30$ dBm</td>
<td>-3</td>
<td>+9</td>
<td>-</td>
<td>dBm</td>
</tr>
<tr>
<td>RF IN return loss</td>
<td>$R_{Li1}$</td>
<td>-</td>
<td>6</td>
<td>13</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>RF OUT return loss</td>
<td>$R_{Lo1}$</td>
<td>-</td>
<td>6</td>
<td>18</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>Gain settling time 1</td>
<td>$T_{S1}$</td>
<td>Bypass to LNA active mode, To be within 1 dB of the final gain</td>
<td>-</td>
<td>0.5</td>
<td>2</td>
<td>μs</td>
</tr>
<tr>
<td>Gain settling time 2</td>
<td>$T_{S2}$</td>
<td>LNA active to bypass mode, To be within 1 dB of the final insertion loss</td>
<td>-</td>
<td>1</td>
<td>2</td>
<td>μs</td>
</tr>
</tbody>
</table>

$^1$: PCB and connector losses: 0.60 dB @ 4900 MHz, 0.64 dB @ 5500 MHz, 0.69 dB @ 5925 MHz
$^2$: PCB and connector losses: 0.27 dB @ 4900 MHz, 0.30 dB @ 5500 MHz, 0.31 dB @ 5925 MHz

**ELECTRICAL CHARACTERISTICS 3 (RF CHARACTERISTICS: Bypass mode)**

$f_{RF} = 4900$ to $5925$ MHz, $V_{DD} = 3.3$ V, $V_{\text{CTL}} = 0$ V, $T_a = 25^\circ\text{C}$, $Z_s = Z_l = 50$ Ω, with application circuit

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>TEST CONDITION</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insertion loss</td>
<td>Loss</td>
<td>Exclude PCB and connector losses $^1$</td>
<td>-</td>
<td>5.5</td>
<td>9</td>
<td>dB</td>
</tr>
<tr>
<td>Input power at 1 dB gain</td>
<td>$P_{1\text{dB(IN)}}$</td>
<td>$f_1 = f_{RF}, f_2 = f_{RF} + 1$ MHz, $P_{IN} = -15$ dBm</td>
<td>0</td>
<td>+9</td>
<td>-</td>
<td>dBm</td>
</tr>
<tr>
<td>Input 3rd order intercept</td>
<td>$I_{\text{IP3_2}}$</td>
<td>$f_1 = f_{RF}, f_2 = f_{RF} + 1$ MHz, $P_{IN} = -15$ dBm</td>
<td>0</td>
<td>+14</td>
<td>-</td>
<td>dBm</td>
</tr>
<tr>
<td>RF IN return loss</td>
<td>$R_{Li2}$</td>
<td>-</td>
<td>4</td>
<td>10</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>RF OUT return loss</td>
<td>$R_{Lo2}$</td>
<td>-</td>
<td>4</td>
<td>11</td>
<td>-</td>
<td>dB</td>
</tr>
</tbody>
</table>

$^1$: PCB and connector losses: 0.60 dB @ 4900 MHz, 0.64 dB @ 5500 MHz, 0.69 dB @ 5925 MHz
- ELECTRICAL CHARACTERISTICS (LNA active mode)

\[ V_{DD} = 3.3 \, \text{V}, \, V_{CTL} = 3.3 \, \text{V}, \, T_a = 25^\circ \text{C}, \, Z_s = Z_i = 50 \, \Omega, \, \text{with application circuit} \]
ELECTRICAL CHARACTERISTICS (LNA active mode)

$V_{DD} = 3.3\,\text{V}$, $V_{CTL} = 3.3\,\text{V}$, $T_a = 25\,\text{°C}$, $Z_s = Z_l = 50\,\Omega$, with application circuit.

**S11 vs frequency**

$(V_{DD}=3.3\,\text{V}, V_{CTL}=3.3\,\text{V})$

**S22 vs frequency**

$(V_{DD}=3.3\,\text{V}, V_{CTL}=3.3\,\text{V})$

**S21 vs frequency**

$(V_{DD}=3.3\,\text{V}, V_{CTL}=3.3\,\text{V})$

**S12 vs frequency**

$(V_{DD}=3.3\,\text{V}, V_{CTL}=3.3\,\text{V})$

(Exclude PCB, connector losses).

---

**Zin**

Freq (50.00MHz to 10.00GHz)

- m1: freq=4.900GHz
  - $S(1,1)=0.251 / 65.532$
  - Impedance = 20 * (1.006 + j0.533)

- m2: freq=5.925GHz
  - $S(1,1)=0.351 / -111.177$
  - Impedance = 20 * (0.637 - j0.478)

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**Zout**

Freq (50.00MHz to 10.00GHz)

- m3: freq=4.900GHz
  - $S(2,2)=0.298 / 38.736$
  - Impedance = 20 * (1.460 + j0.507)

- m4: freq=5.925GHz
  - $S(2,2)=0.051 / -125.265$
  - Impedance = 20 * (0.040 - j0.078)
- ELECTRICAL CHARACTERISTICS (Bypass mode)
  $V_{DD} = 3.3\, \text{V}$, $V_{CTL} = 0\, \text{V}$, $T_a = 25^\circ\text{C}$, $Z_s = Z_l = 50\, \Omega$, with application circuit
ELECTRICAL CHARACTERISTICS (Bypass mode)

$V_{DD} = 3.3\, \text{V}, V_{CTL} = 0\, \text{V}, T_a = 25^\circ\text{C}, Z_s = Z_l = 50\, \Omega$, with application circuit

**S11 vs frequency**

$V_{DD}=3.3\, \text{V}, V_{CTL}=0\, \text{V}$

**S22 vs frequency**

$V_{DD}=3.3\, \text{V}, V_{CTL}=0\, \text{V}$

**S21 vs frequency**

$V_{DD}=3.3\, \text{V}, V_{CTL}=0\, \text{V}$

(Exclude PCB, connector losses)

**S12 vs frequency**

$V_{DD}=3.3\, \text{V}, V_{CTL}=0\, \text{V}$

(Exclude PCB, connector losses)

---

Frequency diagrams with labeled impedances:

- **Zin**:
  - $m_1$: freq: 4.900GHz
  - $S_{11}$: $-0.596 / 138.320$
  - Impedance: $Z_0 \ast (0.311 \pm j0.348)$

- **Zout**:
  - $m_3$: freq: 4.900GHz
  - $S_{21}$: $0.477 / 94.048$
  - Impedance: $Z_0 \ast (0.597 \pm j0.735)$

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http://www.njr.com/
- ELECTRICAL CHARACTERISTICS (LNA active mode)

\[ V_{\text{ctl}} = 3.3 \, \text{V}, \; Z_s = Z_l = 50 \, \Omega, \text{ with application circuit} \]
**ELECTRICAL CHARACTERISTICS (Bypass mode)**

\[ V_{\text{CTL}} = 0 \text{ V, } Z_s = Z_l = 50 \, \Omega, \text{ with application circuit} \]

- **Loss vs. Ambient Temperature**
  \[ (V_{\text{CTL}}=0\text{V}, f=5025\text{MHz}) \]

- **P-1dB(IN) vs. Ambient Temperature**
  \[ (V_{\text{CTL}}=0\text{V}, f=5025\text{MHz}) \]

- **IIP3 vs. Ambient Temperature**
  \[ (V_{\text{CTL}}=0\text{V}, f_1=500\text{MHz}, f_2=5025\text{MHz}, P_{\text{IN}}=-15\text{dBm}) \]

**ELECTRICAL CHARACTERISTICS (DC)**

\[ Z_s = Z_l = 50 \, \Omega, \text{ with application circuit} \]

- **\( I_{\text{OD}1} \) vs. \( V_{\text{DD}} \)**
  \[ (V_{\text{CTL}}=3.3\text{V}) \]

- **\( I_{\text{OD}} \) vs. \( V_{\text{CTL}} \)**
  \[ (V_{\text{DD}}=3.3\text{V}) \]
APPLICATION CIRCUIT

1 Pin Index
(Top view)

VCTL
1

RFIN
2

C1
3

GND
4

VDD
6

Logic, Bias Circuit

Exposed Pad

RFIN

RFOUT

L1 1.3 nH LQP03TN_02 Series (MURATA)

C1 1000 pF GRM03 Series (MURATA)

PARTS LIST

<table>
<thead>
<tr>
<th>Part ID</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>1.3 nH</td>
<td>LQP03TN_02 Series (MURATA)</td>
</tr>
<tr>
<td>C1</td>
<td>1000 pF</td>
<td>GRM03 Series (MURATA)</td>
</tr>
</tbody>
</table>
EVALUATION BOARD PCB LAYOUT

(Top view)

PCB Information
Substrate: FR-4
Thickness: 0.2mm
Microstrip line width: 0.4mm ($Z_0=50\Omega$)
Size: 14.0mm x 14.0mm

<PCB LAYOUT GUIDELINE>

PRECAUTIONS
• All external parts should be placed as close as possible to the IC.
• For good RF performance, all GND terminals (including the exposed pad) must be connected to PCB ground plane of substrate, and via-holes for GND should be placed near the IC.
RECOMMENDED FOOTPRINT PATTERN (ESON6-G1)

PKG: 1.6 mm x 1.6 mm
Pin pitch: 0.5 mm

- Land
- Mask (Open area)  *Metal mask thickness : 100μm
- Resist (Open area)

Units: mm
**Noise Figure Measurement Block Diagram**

**Measuring Instruments**
- NF Analyzer: Keysight N8975A
- Noise Source: Keysight 346A

**Setting the NF Analyzer**
- Measurement mode form
  - Device under test: Amplifier
  - System downconverter: off
- Mode setup form
  - Sideband: LSB
  - Averages: 8
  - Average mode: Point
  - Bandwidth: 4MHz
  - Loss comp: off
  - Tcold: setting the temperature of noise source (305.15K)

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**Calibration Setup**

* Preamplifier is used to improve NF measurement accuracy.
* Noise source, preamplifier and NF analyzer are connected directly.

**Measurement Setup**

* Noise source, DUT, preamplifier and NF analyzer are connected directly.
■ PACKAGE OUTLINE

Unit : mm
Substrate : Cu
Terminal Treat : SnBi
Molding Material : Epoxy Resin
Weight : 0.0035 (g)

Please connect to GND
[ CAUTION ]

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5. Special care is required in designing devices, machinery or equipment which demand high levels of reliability. This is particularly important when designing critical components or systems whose failure can foreseeably result in situations that could adversely affect health or safety. In designing such critical devices, equipment or machinery, careful consideration should be given to amongst other things, their safety design, fail-safe design, back-up and redundancy systems, and diffusion design.

6. The products listed in this datasheet may not be appropriate for use in certain equipment where reliability is critical or where the products may be subjected to extreme conditions. You should consult our sales office before using the products in any of the following types of equipment:
   - Aerospace Equipment
   - Equipment Used in the Deep Sea
   - Power Generator Control Equipment (Nuclear, steam, hydraulic, etc.)
   - Life Maintenance Medical Equipment
   - Fire Alarms / Intruder Detectors
   - Vehicle Control Equipment (Airplane, railroad, ship, etc.)
   - Various Safety Devices

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