WIDE BAND LOW NOISE AMPLIFIER GaAs MMIC

**GENERAL DESCRIPTION**
The NJG1142KA1 is a wide band low noise amplifier GaAs MMIC designed for mobile TV application. And this amplifier can be tuned to wide frequency (170MHz~900MHz). The NJG1142KA1 has a LNA pass-through function to select high gain mode or low gain mode by low control voltage operation. The NJG1142KA1 features low current consumption, high linearity. An ultra-small and ultra-thin package of FLP6-A1 is adopted.

**APPLICATIONS**
Wide band applications from 170MHz to 900MHz
Mobile TV and Digital TV applications
Mobile phone and tablet PC applications

**FEATURES**
- Wide operating frequency range 170MHz~900MHz
- Low voltage operation +2.8V/+1.8V typ.
  - **[High gain mode]**
    - Low current consumption 6mA typ. @Vdd=2.8V
    - High gain +14.0dB typ. @Vdd=2.8V
    - Low noise figure 1.5dB typ. @Vdd=2.8V
    - High P<sub>-0.1dB</sub> Compression 0dBm typ. @Vdd=2.8V
    - High input IP3 +2.0dBm typ. @Vdd=2.8V
  - **[Low gain mode]**
    - Low current consumption 11µA typ. @Vdd=2.8V
    - Gain (Low loss) -1.0dB typ. @Vdd=2.8V
    - High P<sub>-0.1dB</sub> Compression +17dBm typ. @Vdd=2.8V
    - High input IP3 +22.0dBm typ. @Vdd=2.8V
- External components count 3 pcs. (capacitor: 2pcs, inductor: 1pc)
- Small package size FLP6-A1 (package size: 1.6mm x 1.6mm x 0.55mm typ.)
- RoHS compliant and Halogen Free

**PIN CONFIGURATION**

**PIN CONNECTION**
1. VCTL
2. GND
3. RFOUT
4. GND
5. GND
6. RFIN

**TRUTH TABLE**

<table>
<thead>
<tr>
<th>V&lt;sub&gt;CTL&lt;/sub&gt;</th>
<th>LNA Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>High Gain Mode</td>
</tr>
<tr>
<td>L</td>
<td>Low Gain Mode</td>
</tr>
</tbody>
</table>

“H” = V<sub>CTL(H)</sub> “L” = V<sub>CTL(L)</sub>

NOTE: The information on this datasheet is subject to change without notice
|| ABSOLUTE MAXIMUM RATINGS |
|---------------------------|
| PARAMETER                | SYMBOL | CONDITIONS | RATINGS | UNITS |
| Supply voltage           | $V_{DD}$ |            | 5.0     | V     |
| Control voltage          | $V_{CTL}$ |            | 5.0     | V     |
| Input power              | $P_{IN}$ | $V_{DD}=2.8V$ | +15     | dBm   |
| Power dissipation        | $P_{D}$ | 4-layer FR4 PCB with through-hole (74.2mmx74.2mm), $T_j=150°C$ | 580     | mW    |
| Operating temperature    | $T_{opr}$ |            | -40~+85 | °C    |
| Storage temperature      | $T_{stg}$ |            | -55~+150 | °C    |

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<td>DC CHARACTERISTICS</td>
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<tr>
<td>General conditions: $V_{DD}=2.8V$, $T_a=+25°C$, $Z_s=Z_l=50$ ohm, with application circuit</td>
</tr>
</tbody>
</table>

<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>6.0</td>
<td>9.5</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 1

### RF CHARACTERISTICS1 (High Gain Mode)

Conditions: $V_{DD}=2.8\,V$, $V_{CTL}=1.8\,V$, $f_{RF}=170$~900MHz, $T_a=+25^\circ C$, $Z_s=Z_l=50\,\Omega$, with application circuit

<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>11.0</td>
<td>14.0</td>
<td>18.0</td>
<td>dB</td>
</tr>
<tr>
<td>Noise figure1</td>
<td>NF1</td>
<td>Exclude PCB &amp; connector losses*2</td>
<td>-</td>
<td>1.5</td>
<td>1.9</td>
<td>dB</td>
</tr>
<tr>
<td>Input power 1dB gain compression1</td>
<td>$P_{1dB(IN)}$</td>
<td>$-5.0$</td>
<td>0.0</td>
<td>-</td>
<td>dBm</td>
<td></td>
</tr>
<tr>
<td>Input 3rd order intercept point1</td>
<td>$IIP3-1$</td>
<td>$f_1=f_{RF}, f_2=f_{RF}+100kHz, P_{IN}=-26dBm$</td>
<td>-3.0</td>
<td>+2.0</td>
<td>-</td>
<td>dBm</td>
</tr>
<tr>
<td>Isolation1</td>
<td>ISL1</td>
<td>Exclude PCB &amp; connector losses*1</td>
<td>-</td>
<td>-19</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>RF IN VSWR1</td>
<td>VSWRi1</td>
<td>-</td>
<td>1.5</td>
<td>2.3</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:
0.035dB(at 170MHz), 0.088dB(620MHz), 0.120dB(at 900MHz)

*2 Input PCB and connector losses:
0.018dB(170MHz), 0.044dB(620MHz), 0.060dB(900MHz)

## ELECTRICAL CHARACTERISTICS 1

### RF CHARACTERISTICS2 (Low Gain Mode)

Conditions: $V_{DD}=2.8\,V$, $V_{CTL}=0\,V$, $f_{RF}=170$~900MHz, $T_a=+25^\circ C$, $Z_s=Z_l=50\,\Omega$, with application circuit

<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 gain2</td>
<td>Gain2</td>
<td>Exclude PCB &amp; connector losses*1</td>
<td>-2.5</td>
<td>-1.0</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>Input power at 1dB gain compression2</td>
<td>$P_{1dB(IN)}$</td>
<td>$+14.0$</td>
<td>$+17.0$</td>
<td>-</td>
<td>dBm</td>
<td></td>
</tr>
<tr>
<td>Input 3rd order intercept point2</td>
<td>$IIP3-2$</td>
<td>$f_1=f_{RF}, f_2=f_{RF}+100kHz, P_{IN}=-8dBm$</td>
<td>$+17.0$</td>
<td>$+22.0$</td>
<td>-</td>
<td>dBm</td>
</tr>
<tr>
<td>RF IN VSWR2</td>
<td>VSWRi2</td>
<td>-</td>
<td>1.5</td>
<td>2.0</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>RF OUT VSWR2</td>
<td>VSWRo2</td>
<td>-</td>
<td>1.5</td>
<td>2.0</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

*1 Input & output PCB and connector losses:
0.035dB(at 170MHz), 0.088dB(620MHz), 0.120dB(at 900MHz)
ELECTRICAL CHARACTERISTICS 2

**DC CHARACTERISTICS**

General conditions: $V_{DD}=1.8V$, $T_a=+25^\circ C$, $Z_s=Z_l=50$ ohm, with application circuit

<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>1.8</td>
<td>-</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>Control voltage (High)</td>
<td>$V_{CTL(H)}$</td>
<td>-</td>
<td>1.8</td>
<td>-</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>Control voltage (Low)</td>
<td>$V_{CTL(L)}$</td>
<td>-</td>
<td>0.0</td>
<td>-</td>
<td>-</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>4.2</td>
<td>-</td>
<td>mA</td>
</tr>
<tr>
<td>Operating current2</td>
<td>$I_{DD2}$</td>
<td>RF OFF, $V_{CTL}=0V$</td>
<td>-</td>
<td>6.4</td>
<td>-</td>
<td>$\mu$A</td>
</tr>
<tr>
<td>Control current</td>
<td>$I_{CTL}$</td>
<td>RF OFF, $V_{CTL}=1.8V$</td>
<td>-</td>
<td>5.6</td>
<td>-</td>
<td>$\mu$A</td>
</tr>
</tbody>
</table>

**RF CHARACTERISTICS1 (High Gain Mode)**

Conditions: $V_{DD}=1.8V$, $V_{CTL}=1.8V$, $f_{RF}=170$~$900$MHz, $T_a=+25^\circ C$, $Z_s=Z_l=50$ohm, with application circuit

<table>
<thead>
<tr>
<th>PARAMETERS</th>
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<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>-</td>
<td>12.1</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>Noise figure1</td>
<td>NF1</td>
<td>Exclude PCB &amp; connector losses*2</td>
<td>-</td>
<td>1.75</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>Input power 1dB gain compression1</td>
<td>$P_{1dB(IN)}$</td>
<td>-</td>
<td>-1.6</td>
<td>-</td>
<td>dBm</td>
<td></td>
</tr>
<tr>
<td>Input 3rd order intercept point1</td>
<td>IIP3_1</td>
<td>$f_1=f_{RF}$, $f_2=f_{RF}+100$kHz, $P_{IN}=-26$dBm</td>
<td>-</td>
<td>+2.0</td>
<td>-</td>
<td>dBm</td>
</tr>
<tr>
<td>Isolation1</td>
<td>ISL1</td>
<td>Exclude PCB &amp; connector losses*1</td>
<td>-</td>
<td>-18.4</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>RF IN VSWR1</td>
<td>VSWRI1</td>
<td>-</td>
<td>1.67</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>RF OUT VSWR1</td>
<td>VSWRo1</td>
<td>-</td>
<td>1.96</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

*1 Input and output PCB, connector losses :
0.035dB(at 170MHz), 0.088dB(at 620MHz), 0.120dB(at 900MHz)

*2 Input PCB, connector losses :
0.018dB(at 170MHz), 0.044dB(at 620MHz), 0.060dB(at 900MHz)
ELECTRICAL CHARACTERISTICS 2
RF CHARACTERISTICS2 (Low Gain Mode)
Conditions: V_{DD}=1.8V, V_{CTL}=0V, f_{RF}=170~900MHz, T_{a}=+25^\circ C, Z_{s}=Z_{l}=50\text{ohm}, with application circuit

<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 gain2</td>
<td>Gain2</td>
<td>Exclude PCB &amp; connector losses*1</td>
<td>-</td>
<td>-1.1</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>Input power at 1dB gain compression2</td>
<td>P_{1dB(IN)2}</td>
<td></td>
<td>-</td>
<td>+18.9</td>
<td>-</td>
<td>dBm</td>
</tr>
<tr>
<td>Input 3rd order intercept point2</td>
<td>IIP3_2</td>
<td>f_1=f_{RF}, f_2=f_{RF}+100kHz, P_{IN}=-8dBm</td>
<td>-</td>
<td>+24.0</td>
<td>-</td>
<td>dBm</td>
</tr>
<tr>
<td>RF IN VSWR2</td>
<td>VSWRi2</td>
<td></td>
<td>-</td>
<td>1.33</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>RF OUT VSWR2</td>
<td>VSWR02</td>
<td></td>
<td>-</td>
<td>1.15</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*1 Input and output PCB, connector losses:

0.035dB(at 170MHz), 0.088dB(at 620MHz), 0.120dB(at 900MHz)

TERMINAL INFORMATION

<table>
<thead>
<tr>
<th>No.</th>
<th>SYMBOL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VCTL</td>
<td>Control voltage supply terminal.</td>
</tr>
<tr>
<td>2</td>
<td>GND</td>
<td>Ground terminal. These terminals 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 is also the power supply terminal of the LNA. please use inductor (L1) to connect power supply.</td>
</tr>
<tr>
<td>4</td>
<td>GND</td>
<td>Ground terminal. These terminals should be connected to the ground plane as close as possible for excellent RF performance.</td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
<td>Ground terminal. These terminals 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 is integrated an input DC blocking capacitor.</td>
</tr>
</tbody>
</table>
ELECTRICAL CHARACTERISTICS (High Gain Mode)
(Condition : Ta=+25°C, V_{DD}=2.8V, V_{CTL}=1.8V, Z_s=Z_l=50ohm, with application circuit)

- Pout vs. Pin
  (freq=620MHz)
- Gain, I_{BO} vs. Pin
  (freq=620MHz)
- Pout, IM3 vs. Pin
  (f_1=620MHz, f_2=f_1+100kHz)
- NF, Gain vs. frequency
  (freq=50~2000MHz)
- P-1dB(IN) vs. frequency
  (freq=50~2000MHz)
- IIP3, OIP3 vs. frequency
  (f_1=50~2000MHz, f_2=f_1+100kHz, Pin=-26dBm)
ELECTRICAL CHARACTERISTICS (High Gain Mode)
(Condition: Ta=+25°C, V_CTL=1.8V, Zs=Zl=50ohm, with application circuit)
ELECTRICAL CHARACTERISTICS (High Gain Mode)
(Condition: \(V_{DD}=2.8\text{V}, V_{CTL}=1.8\text{V}, Z_s=Z_l=50\text{ohm}, \text{with application circuit}\))

- **NF, Gain vs. Temperature**
  - Frequency: 620MHz

- **P-1dB(IN) vs. Temperature**
  - Frequency: 620MHz

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

- **VSWR vs. Temperature**
  - Frequency: 620MHz

- **Isolation vs. Temperature**
  - Frequency: 620MHz

- **\(I_{OD}, I_{CTL} vs. Temperature\)**
  - (RF OFF)
ELECTRICAL CHARACTERISTICS (High Gain Mode)
(Condition: $T_a=+25^\circ C$, $V_{DD}=2.8V$, $V_{CTL}=1.8V$, $Z_s=Z_l=50\text{ohm}$, with application circuit)

$S_{11}$, $S_{22}$

$S_{21}$, $S_{12}$

$VSWR_i$, $VSWR_o$

$Z_{in}$, $Z_{out}$
ELECTRICAL CHARACTERISTICS (High Gain Mode)
(Condition: \( T_a = +25^\circ C \), \( V_{DD} = 2.8V \), \( V_{CTL} = 1.8V \), \( Z_s = Z_l = 50\) ohm, with application circuit)

K factor vs. frequency
(freq=50MHz~20GHz)
ELECTRICAL CHARACTERISTICS (Low Gain Mode)
(Condition : $T_a=+25^\circ C$, $V_{DD}=2.8V$, $V_{CTL}=0V$, $Z_s=Z_l=50\text{ohm}$, with application circuit)

- **Pout vs. Pin**
  (freq=620MHz)

- **Gain, $I_{DE}$ vs. Pin**
  (freq=620MHz)

- **Pout, IM3 vs. Pin**
  ($f_1=620MHz$, $f_2=f_1+100kHz$)

- **Gain vs. frequency**
  (freq=50~2000MHz)

- **P-1dB(IN) vs. frequency**
  (freq=50~2000MHz)

- **IIP3, OIP3 vs. frequency**
  ($f_1=50~2000MHz$, $f_2=f_1+100kHz$, $Pin=-8\text{dBm}$)
ELECTRICAL CHARACTERISTICS (Low Gain Mode)

(Condition : Ta=+25°C, V_{CTL}=0V, Z_s=Z_l=50ohm, with application circuit)
ELECTRICAL CHARACTERISTICS (Low Gain Mode)
(Condition: \( V_{DD} = 2.8V \), \( V_{CTL} = 0V \), \( Z_s = Z_l = 50\text{ohm} \), with application circuit)

- **Gain vs. Temperature**
  - Frequency: 620MHz

- **P-1dB(IN) vs. Temperature**
  - Frequency: 620MHz

- **IIP3, OIP3 vs. Temperature**
  - Frequency: 620MHz, \( f_2 = f_2 + 100kHz \), \( P_{in} = -8\text{dBm} \)

- **VSWR vs. Temperature**
  - Frequency: 620MHz

- **\( I_{DD} \) vs. Temperature**
  - (RF OFF)

- **\( I_{DD} \) vs. \( V_{CTL} \)**
  - (RF OFF)

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**New Japan Radio Co., Ltd.**
ELECTRICAL CHARACTERISTICS (Low Gain Mode)
(Condition : $T_a=+25^\circ C$, $V_{DD}=2.8V$, $V_{CTL}=0V$, $Z_s=Z_l=50\text{ohm}$, with application circuit)
ELECTRICAL CHARACTERISTICS (Low Gain Mode)
(Condition: $T_a=+25^\circ C$, $V_{DD}=2.8V$, $V_{CTL}=0V$, $Z_s=Z_l=50\text{ohm}$, With application circuit)

S11, S22 (50MHz~20GHz)

S21, S12 (50MHz~20GHz)

K factor vs. frequency
(freq=50MHz~20GHz)
**APPLICATION CIRCUIT**

(Top View)

- **L1**: TAIYO-YUDEN HK1005 Series
- **C1, C2**: MURATA GRM15 Series

**NOTES:**
- L1 is an RF choke. (DC feed inductor)
- C1 is a coupling and DC blocking capacitor at the output.
- C2 is a bypass capacitor.

**TEST PCB LAYOUT**

(Top View)

**PARTS LIST**

<table>
<thead>
<tr>
<th>Parts ID</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>TAIYO-YUDEN HK1005 Series</td>
</tr>
<tr>
<td>C1, C2</td>
<td>MURATA GRM15 Series</td>
</tr>
</tbody>
</table>

**NOTES:**
- In order not to couple with terminal RFIN and RFOUT, please layout ground pattern under the IC.

**PRECAUTION:**
- In order not to couple with terminal RFIN and RFOUT, please layout ground pattern under the IC.

**PCB (FR-4):**
- $t=0.2\text{mm}$
- MICROSTRIP LINE WIDTH $=0.40\text{mm}$ ($Z_0=50\Omega$)
- PCB SIZE $=16.8\text{mm} \times 16.8\text{mm}$
### MEASUREMENT BLOCK DIAGRAM

- **S parameter Measurements**

![S parameter Measurement Block Diagram](image)

- **IIP3 Measurements**

![IF and IM3 Measurement Block Diagram for IIP3 (High Gain Mode)](image)

![IF and IM3 Measurement Block Diagram for IIP3 (Low Gain Mode)](image)
● Noise Figure Measurements

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 : 8
Average mode : Point
Bandwidth : 4MHz
Loss comp : off
Tcold : setting the temperature of noise source (300.0K)

Calibration Setup
Noise Source
(Agilent 346A)
Input (50Ω)
NF Analyzer
(Agilent 8973A)
Noise Source Drive Output

Measurement Setup
Noise Source
(Agilent 346A)
DUT
Input (50Ω)
NF Analyzer
(Agilent 8973A)
Noise Source Drive Output

* Noise source and NF analyzer are connected directly.
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.

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