NEC / CEL Components

For

2.4GHz ZigBee and ISM Band Applications
Components for 2.4 GHz Designs
Bluetooth, ZigBee, ISM Band Transmitters

SPDT Switches*:
- uPG2214TB/TK
- uPG2030TK
- uPG2179TB
- uPG2158T5K
- uPG2012TK
- uPG2015TB

LNA Devices:
- NESG3031M05/M14
- NE662M04
- NE3508M04
- uPC8233TK

SP3T Switch:
- uPG2150T5L

PA ICs:
- uPG2314T5N
- uPG2301TQ
- uPG2250T5N

*See page on power considerations for switches
## Quick Guide:

<table>
<thead>
<tr>
<th>P/N</th>
<th>Pout (typical, at T=25C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>uPG2314T5N</td>
<td>+20 dBm at 3V</td>
</tr>
<tr>
<td>uPG2301TQ</td>
<td>+23 dBm at 3.3V</td>
</tr>
<tr>
<td>uPG2250T5N</td>
<td>+20 dBm at 1.8V</td>
</tr>
<tr>
<td>uPG2250T5N</td>
<td>+25 dBm at 3V</td>
</tr>
</tbody>
</table>
**Features**
- Low Current Consumption
- 20dB Variable Gain Control
- Shut Down Function
- Smaller & Lower Height Package

**Applications**
- Bluetooth Class 1, ZigBee, ISM Band

**Performance (typical)**
- Frequency: 2.4 to 2.5GHz
- Supply voltage: $V_{CC1,2} = V_{bias} = V_{enable} = 3V$
- Output Power: $+20dBm @ V_{cont} = 3V, Pin=+0dBm$
- Gain Control Range: $\Delta G=20dB \quad @ V_{cont} = 0$ to $3.0V, Pin=+0dBm$
- Operating Current: 65 mA typ. @ Pin=+0dBm, $V_{cont} = 3V$
uPG2314T5N Evaluation Board Layout

Total Parts: 6pcs
uPG2314T5N Evaluation Board Schematic

Total ; 6pcs

uPG2314T5N

Vcc1

Ven+Vbias

Vcont

Vcc2

Pout

Pin

3.9nH

2.7nH

1nF

22nH

10pF

1nF
Test Conditions: \( f = 2450\text{MHz}, V_{cc1} = V_{cc2} = V_{bias} + V_{enable} = V_{cont} = 3.0\text{V}, \)
with external input & output matching circuits
Test Conditions: f = 2450MHz, Vcc1 = Vcc2 = Vbias + Venable = 3.0V, Pin = +0dBm, with external input & output matching circuits
uPG2314T5N Ven+Vbias vs. Pout, PAE, Icc

Test Conditions: f = 2450MHz, Vcc1 = Vcc2 = Vcont = 3.0V, Pin = +0dBm, with external input & output matching circuits
**Features**
- Low Current Consumption
- 20dB Variable Gain Control
- Shut Down Function

**Applications**
- Bluetooth, ZigBee, ISM Band

**RF Performance (typical)**
- Frequency: 2.4 to 2.5GHz
- Supply voltage: $V_{CC1,2} = V_{bias} = 3.3V$, $V_{enable} = 2.9V$
- Output Power: $+23\text{dBm} \ @ V_{cont} = 2.5V$, $Pin=+4\text{dBm}$
- Gain Control Range: $23\text{dB} \ @ V_{cont} = 0 \text{ to } 2.5V$, $Pin=+4\text{dBm}$
- Operating Current: $120\text{mA typ.} \ @ Pin=+4\text{dBm}$, $V_{cont} = 2.5V$
- Harmonics @ $+20\text{dBm}$ Output, $V_{cc} = 3.3V$, $I_{cc} = 100\text{mA}$
  
  - $2f_0$: 49 dBc
  - $3f_0$: 40 dBc
  - $4f_0$: 54 dBc
  - $5f_0$: 60 dBc
uPG2301TQ Evaluation Circuit

Only 8 pcs of external 0603 size chip components are needed
Test Conditions: f = 2450MHz, Vcc1 = Vcc2 = Vbias = 3.3V, Venable = 2.9V, Vcont = 2.5V, with external input & output matching circuits.
Test Conditions: $f = 2450\text{MHz}, V_{cc1} = V_{cc2} = V_{bias} = 3.3\text{V}, V_{enable} = 2.9\text{V},$ $P_{in} = 4\text{dBm}$, with external input & output matching circuits.
uPG2301TQ Venable vs. Pout, PAE, Icc

Test Conditions: $f = 2450\text{MHz}, Vcc_1 = Vcc_2 = Vbias = 3.3\text{V}, Vcont = 2.5\text{V}, Pin = +4\text{dBm}$,

With external input & output matching circuits

- **Pout**
- **PAE**
- **Icc**
Features

- 1.8V to 3.0V Operation
- Shut Down Function
- 0.4mm Lower Height Package

Applications

- Bluetooth Class 1 EDR, ZigBee, ISM Band

Preliminary Performance (Typical)

- Frequency Range: 2.4 to 2.5GHz
- Supply voltage: Vdd = 3.0V or 1.8V, Vcont = 1.8V
- Output Power: +25dBm, Vdd = 3.0V
  +20dBm, Vdd = 1.8V
  @Vcont = 1.8V, Pin = -2dBm
- Current: 190mA @ Pout = +25dBm, Vdd = 3.0V
  110mA @ Pout = +20dBm, Vdd = 1.8V

6pin TSON PKG

1.5x1.5x0.4 mm
(0.5mm pitch)
COMPONENTS OF TEST CIRCUIT

<table>
<thead>
<tr>
<th>Parts</th>
<th>Part Number</th>
<th>Maker</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chip Capacitor</td>
<td>GRM1552C1H100JZ01</td>
<td>Murata</td>
<td>C1</td>
<td>10pF</td>
</tr>
<tr>
<td>Chip Capacitor</td>
<td>GRM1554C1H1R5CZ01</td>
<td>Murata</td>
<td>C2</td>
<td>1.5pF</td>
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<tr>
<td>Chip Capacitor</td>
<td>GRM1552C1H102JA01</td>
<td>Murata</td>
<td>C3</td>
<td>1000pF</td>
</tr>
<tr>
<td>Chip Capacitor</td>
<td>GRM155B31C104KA87</td>
<td>Murata</td>
<td>C4～C7</td>
<td>0.1μF</td>
</tr>
<tr>
<td>Chip Inductor</td>
<td>LL1005-FHL5N6S</td>
<td>TOKO</td>
<td>L1</td>
<td>5.6nH</td>
</tr>
<tr>
<td>Chip Inductor</td>
<td>LL1005-FHL2N2S</td>
<td>TOKO</td>
<td>L2</td>
<td>2.2nH</td>
</tr>
<tr>
<td>Chip Inductor</td>
<td>LL1005-FHL12NJ</td>
<td>TOKO</td>
<td>L3</td>
<td>12nH</td>
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<tr>
<td>RF Connector</td>
<td>01K2266-00</td>
<td>WAKA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total ;10pcs (005size)
uPG2250T5N Pin vs. Pout, PAE, Icc

Test Conditions: $f = 2450$ MHz, $V_{dd1} = V_{dd2} = V_{dd3} = 3.0$ V, $V_{cont} = 1.8$ V
with external input & output matching circuits

$V_{dd} = 3$ V
**uPG2250T5N Vcont vs. Pout, PAE, Icc**

Vdd = 3V

**Test Conditions**: f = 2450MHz, Vdd1=Vdd2=Vdd3=3.0V, Pin=-5dBm with external input & output matching circuits

(Reference Only)
Test Conditions: $f = 2450$ MHz, $\text{Vdd}_1 = \text{Vdd}_2 = \text{Vdd}_3 = 1.8$ V, $V_{\text{cont}} = 1.8$ V

with external input & output matching circuits

Vdd = 1.8V

Vdd = 1.8V
Test Conditions: $f = 2450\text{MHz}$, $V_{dd1}=V_{dd2}=V_{dd3}=1.8\text{V}$, $P_{in}=-5\text{dBm}$

with external input & output matching circuits

$V_{dd} = 1.8\text{V}$
2.4GHz Application Example

2.4GHz ISM Band / ZigBee Transceiver

Tx/Rx

MC13203
MC13213

Also
Ember EM250/260
ATMEL AT86RF230
TI Chipcon cc2430/2500
ST Micro SN250
Nordic nRF2401A

CEL Range Extension Solution

Transceiver
Single Ended
Matching Network

Tx: 0 dBm
Rx

Tx: +24 dBm

UPG2214TB
UPG2250T5N
UPG2179TB
+25dBm GaAs PA IC
uPG2251T6M

**Features**
- 2.4 – 2.5GHz, Internally Matched
  - 6 External Components
- 2.5V to 3.6V Operation with Vcont = 1.8V
- Shut Down Function

**Applications**
- Bluetooth Class 1 EDR, ZigBee, ISM Band

**Preliminary Performance (Typical)**
- Frequency Range: 2.4 to 2.5GHz
- Supply voltage: Vdd = 3.0V, Vcont = 1.8V
- Output Power: +25dBm, Pin = -5dBm
- Harmonics: 2fo -35dBc @+25dBm out 3fo -27dBc
- Current: 240mA @ Pout = +25dBm, Vdd = 3.0V @Vcont = 1.8V, Pin = -5dBm

DS: Oct’08
MP: Feb’09

NEW

12-pin TSQFN
2.0 x 2.0 x 0.37 mm
Pout vs. Ga, PAE, Idd Characteristics

Vdd1=Vdd2=Vdd3=3V; Vcont=1.8V

- Pout (dBm), Gain (dB)
- Idd (mA), PAE (%)

- 2.45G
- 2.4G
- 2.5G
## Measured Data

<table>
<thead>
<tr>
<th>Device</th>
<th>Frequency</th>
<th>Bias</th>
<th>$P_{\text{SAT}}$</th>
<th>Eval Boards In Stock</th>
<th>Range Extender Boards (SW-PA-SW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>uPG2314T5N</td>
<td>915 MHz</td>
<td>3.0 V</td>
<td>+20 dBm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.4 GHz</td>
<td>3.0 V</td>
<td>+19.5 dBm</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>uPG2301TQ</td>
<td>915 MHz</td>
<td>3.3 V</td>
<td>+22.8 dBm</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>2.4 GHz</td>
<td>3.3 V</td>
<td>+22.8 dBm</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>uPG2250T5N</td>
<td>915 MHz</td>
<td>3.0 V</td>
<td>+25.5 dBm</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.4 GHz</td>
<td>3.0 V</td>
<td>+25.0 dBm</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>uPG2118K</td>
<td>915 MHz</td>
<td>3.2 V</td>
<td>+31.5 dBm</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.4 GHz</td>
<td>3.2 V</td>
<td>+30.5 dBm</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>
Switches
Better to operate below the min P(0.1) dB point to assure the switch will not contribute excess loss.

Never want to operate at P1dB, switch loss will be ~1.4 dB, high power / heat dissipation in the pkg, highly non-linear, possible reliability risk.

Just starting to compress by 0.1 dB.
### P(0.1 dB) Points of NEC-CEL SPDT Switches

<table>
<thead>
<tr>
<th>Part No.</th>
<th># of Controls</th>
<th>Package Size (mm)</th>
<th>Pin (0.1 dB) (dBm) Minimum</th>
<th>Pin (0.1 dB) (dBm) Typical</th>
<th>Voltage for P(0.1 dB) Spec</th>
</tr>
</thead>
<tbody>
<tr>
<td>uPD5713TK</td>
<td>1</td>
<td>1.5 x 1.3 x 0.55</td>
<td>+13.0</td>
<td>+17.0</td>
<td>2.8V</td>
</tr>
<tr>
<td>uPG2012TK</td>
<td>1</td>
<td>1.5 x 1.3 x 0.55</td>
<td>+17.5</td>
<td>+20.5</td>
<td>2.8V</td>
</tr>
<tr>
<td>uPG2012TB</td>
<td>1</td>
<td>2.0 x 2.1 x 0.90</td>
<td>+17.5</td>
<td>+20.5</td>
<td>2.8V</td>
</tr>
<tr>
<td>uPG2160T5K</td>
<td>1</td>
<td>1.0 x 1.0 x 0.37</td>
<td>+18.0</td>
<td>+21.0</td>
<td>2.6V</td>
</tr>
<tr>
<td>uPG2015TB</td>
<td>1</td>
<td>2.0 x 2.1 x 0.90</td>
<td>+25.5</td>
<td>+27.0</td>
<td>2.8V</td>
</tr>
<tr>
<td>uPG2010TB</td>
<td>1</td>
<td>2.0 x 2.1 x 0.90</td>
<td>+31.5</td>
<td>+33.0</td>
<td>2.8V</td>
</tr>
<tr>
<td>uPG2159T6R</td>
<td>2</td>
<td>1.0 x 1.0 x 0.37</td>
<td>+20.0</td>
<td>+22.0</td>
<td>2.7V</td>
</tr>
<tr>
<td>uPG2214TK</td>
<td>2</td>
<td>1.5 x 1.3 x 0.55</td>
<td>+21.0</td>
<td>+23.0</td>
<td>3.0V</td>
</tr>
<tr>
<td>uPG2214TB</td>
<td>2</td>
<td>2.0 x 2.1 x 0.90</td>
<td>+21.0</td>
<td>+23.0</td>
<td>3.0V</td>
</tr>
<tr>
<td>uPG2163T5N</td>
<td>2</td>
<td>1.5 x 1.5 x 0.37</td>
<td>No Spec</td>
<td>Approx +28</td>
<td>3.0V</td>
</tr>
<tr>
<td>uPG2185T6R</td>
<td>2</td>
<td>1.0 x 1.0 x 0.37</td>
<td>No Spec</td>
<td>Approx +28</td>
<td>3.0V</td>
</tr>
<tr>
<td>uPG2030TK</td>
<td>2</td>
<td>1.5 x 1.3 x 0.55</td>
<td>+25.5</td>
<td>+27.0</td>
<td>2.8V</td>
</tr>
<tr>
<td>uPG2179TB</td>
<td>2</td>
<td>2.0 x 2.1 x 0.90</td>
<td>+25.5</td>
<td>+29.0</td>
<td>3.0V</td>
</tr>
<tr>
<td>uPG2158T5K</td>
<td>2</td>
<td>1.0 x 1.0 x 0.37</td>
<td>+26.0</td>
<td>+29.0</td>
<td>2.7V</td>
</tr>
<tr>
<td>uPG2009TB</td>
<td>2</td>
<td>2.0 x 2.1 x 0.90</td>
<td>+32.5</td>
<td>+34.0</td>
<td>2.8V</td>
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<tr>
<td>uPG2157T5F</td>
<td>2</td>
<td>3.0 x 3.0 x 0.75</td>
<td>No Spec</td>
<td>Approx +34</td>
<td>3.0V</td>
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<tr>
<td>uPG2176T5N</td>
<td>2</td>
<td>1.5 x 1.5 x 0.37</td>
<td>No Spec</td>
<td>Approx +34</td>
<td>3.0V</td>
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<tr>
<td>uPG2155TB</td>
<td>2</td>
<td>2.0 x 2.1 x 0.90</td>
<td>No Spec</td>
<td>+37.5</td>
<td>2.6V</td>
</tr>
</tbody>
</table>

These switches can be used at various voltages. P(0.1 dB) is highly dependent on the applied voltage.
# Recommended PA – Switch Pairs

PA operated at or near saturation

<table>
<thead>
<tr>
<th>PA</th>
<th>$P_{SAT}$</th>
<th>Output Switch IC</th>
<th>$P_{0.1dB}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>uPG2314T5N</td>
<td>+20 dBm</td>
<td>uPG2214TB/TK</td>
<td>+23 dBm (Typ)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>+21 dBm (Min)</td>
</tr>
<tr>
<td>uPG2301TQ</td>
<td>+23 dBm</td>
<td>uPG2179TB</td>
<td>+29 dBm (Typ)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>+25.5 dBm (Min)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>uPG2030TK</td>
<td>+27 dBm (Typ)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>+25.5 dBm (Min)</td>
</tr>
<tr>
<td>uPG2250T5N</td>
<td>+25 dBm</td>
<td>uPG2179TB</td>
<td>+29 dBm (Typ)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>+25.5 dBm (Min)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>uPG2030TK</td>
<td>+27 dBm (Typ)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>+25.5 dBm (Min)</td>
</tr>
</tbody>
</table>

uPG2214TB is recommended as the lowest cost input switch.
Compact SPDT

**uPG2214TB / TK**

**Features**
- Low insertion loss, high isolation
- Specified at 1.8V (as well as 3V)
- Two Package Choices

**Applications**
- Mobile Comm., 802.11b/g, Bluetooth, ZigBee

**Performance (typical)**
- Frequency: 50 MHz to 3.0 GHz
- Control Voltage: +1.8 to 5.3 / 0V (3.0V typ)
- Insertion Loss: 0.35dB @ 2.5GHz
- Isolation: 26dB @ 2.5GHz
- Pin (0.1dB): +23dBm typ. @ +3.0V / 0V
- Pin (0.1dB): +21dBm Min. @ +3.0V / 0V
- Pin (0.1 dB): +16 dBm typ @ +1.8V / 0V

**In Mass Production**

**TB Package**
(SC-70 / SOT-363)
2.0 x 2.1 x 0.9 mm

**TK Package**
1.5 x 1.3 x 0.55 mm

Low Cost Switch for Bluetooth & ZigBee
**uPG2012TK**

**Features**
- 2.8V Single Control Voltage
- Two package choices

**Applications**
- Mobilecomm., Bluetooth, ZigBee

**RF Performance (typical)**
- Frequency: 500 MHz to 2.5 GHz
- Control Voltage: +2.8V / 0V, VDD=+2.8V
- Insertion Loss: 0.30dB @ 2.5GHz
- Isolation: 25dB @ 2.5GHz (TB) 30dB @ 2.5GHz (TK)

- Pin(0.1dB): +20.5dBm Typ @ +2.8V / 0V
- Pin(0.1dB): +17.5dBm Min @ +2.8V / 0V
- Pin(1 dB): +24.0dBm @ +2.8V / 0V
- Switching Speed: 300nS typ.

**In Mass Production**

**TB Package**
( SC-70 / SOT-363 )
2.0 x 2.1 x 0.9 mm

**TK Package**
1.5 x 1.3 x 0.55 mm

Designed into ZigBee reference designs
Comparison of TK and TB Packages

uPG2012 and uPG2214 are available in both TB and TK packages.

Industry Standard
SOT-363 / SC-70
and
NEC’s “TB” package

NEC’s “TK” package
Medium Power, Single Control SPDT

uPG2015TB

Concept
- 2.8V Single Control Voltage (2.7-3.0V)

Application
- 800MHz to 2.5GHz band Mobile Comm., Bluetooth, ZigBee, ISM Band Transceivers

RF Performance
- Frequency: $f = 500M$ to 2.5GHz
- Supply Voltage: $V_{\text{CONT}} = +2.8V / 0V$, $V_{\text{DD}} = +2.8V$
- Insertion Loss: $L_{\text{INS}} = 0.35dB$ typ. @ $f=2.5GHz$
- Isolation: $I_{\text{SL}} = 25dB$ typ. @ $f=2.5GHz$
- Pin(0.1dB): $+27.0dBm$ typ. @ $V_{\text{CONT}} = +2.8V / 0V$
- Pin(0.1dB): $+25.5dBm$ Min. @ $V_{\text{CONT}} = +2.8V / 0V$
- Switching Speed: $t_{\text{sw}} = 300nS$ typ.
- 6pin Super Mini Mold Package (SOT-363 style)
Medium Power SPDT

uPG2179TB

Features
- Low insertion loss and high isolation

Applications
- 802.11b/g, Bluetooth, ZigBee
- Mobilecomm

Performance (typical)
- Frequency Range: 500 MHz to 3.0 GHz
- Control Voltage: +2.5V to +5.3V, 0V
- Insertion Loss: 0.35dB typ @ 2.5GHz
- Isolation: 27dB typ @ 2.5 GHz
- P(1.0 dB): +32 dBm typ
- P(0.1dB): +29 dBm typ
- P(0.1dB): +25.5 dBm min

Industry Best 1-1.5W SPDT
Compact Medium Power SPDT in a Smaller Package

**uPG2030TK**

- **Features**
  - Low insertion loss and high isolation

- **Applications**
  - WLAN 802.11b/g, Mobilecomm
  - Bluetooth, ZigBee

- **Performance (typical)**
  - Frequency: 500 MHz to 2.5 GHz
  - Control Voltage: +2.8V / 0V
  - Insertion Loss: 0.35 dB @ 2.5GHz
  - Isolation: 25 dB @ 2.5GHz
  - Pin(0.1 dB): +27dBm @ +2.8V
  - Switching Speed: 50nS typ.

---

In Mass Production

Block Diagram & Package Dimensions

PKG Height: 0.6mm MAX

A Business Partner of NEC Electronics Corporation.
Ultra Compact SPDT Switch

uPG2158T5K

Features
- Smaller, thin Package
- Alternative to chips for thin modules

Applications
- Mobilecomm, 802.11b,g, Bluetooth, ZigBee
  Antenna diversity, LO and BPF switching

Performance (typical)
- Frequency: 0.05 to 3.0GHz
- Supply Voltage: +1.8 to 5.3 / 0V (2.7V typ)
- Insertion Loss: 0.47 dB @ 2.5 GHz
- Isolation: 17 dB @ 2.5 GHz
- Pin(0.1dB): +29.0dBm @ +2.7V / 0V
- Small Package: 1.0 x 1.0 x 0.37mm

Also specified at 1.8V
### Features
- High Isolation between WiFi Tx and BT port
- Low Height Small Package

### Applications
- 802.11b/g + Bluetooth
- 2.4GHz-Band Communications

### Performance (Typical, at Vc=2.85V)
- Frequency: 2.4 to 2.5GHz
- Control voltage: +2.85V / 0V
- Insertion Loss: 0.50dB @ 2.5GHz (RF1,RF2)
- Insertion Loss: 0.60 dB @ 2.5 GHz (RF3)
- Isolation: 35 dB @ 2.5 GHz WiFi Tx- BT
- Pin (1dB): TX, BT : +31 dBm
- Package: 10pin 2.0 x 2.0 x 0.4mm
Explanation of typical application for this switch:

The uPG2150T5L SP3T switch has been designed specifically for devices that enable both Wi-Fi (802.11 b/g) and Bluetooth connectivity. A typical application diagram would look like the one on the right:

The first two outputs (RF1 and RF2) are used for the transmit and receive sides (respectively) of the Wi-Fi RF solution. And the third output handles the Bluetooth communications, with another T/R switch to handle the Bluetooth transmit and receive functions.

The performance of the uPG2150T5L has been specified with this kind of application in mind, with extra isolation (35dB) provided for the RF3 port in particular.

The three diagrams below summarize the different possible cases with the corresponding isolation values for each path.
2.4GHz LNA Devices
# 2.4GHz LNAs

<table>
<thead>
<tr>
<th></th>
<th>NE662M04 Si XSTR</th>
<th>NESG3031M05 SiGe XSTR</th>
<th>NE3508M04 GaAs FET</th>
<th>uPC8233TK SiGe:C IC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gain</strong></td>
<td>12.4 dB</td>
<td>12.6 dB</td>
<td>13 dB</td>
<td>16.6 dB</td>
</tr>
<tr>
<td><strong>NF</strong></td>
<td>1.5 dB</td>
<td>0.9 dB</td>
<td>0.8 dB</td>
<td>1.3 dB</td>
</tr>
<tr>
<td><strong>Input P₁dB</strong></td>
<td>-11 dBm (-7 dBm)</td>
<td>-7 dBm (-5 dBm)</td>
<td>+1 dBm</td>
<td>-20 dBm</td>
</tr>
<tr>
<td><strong>Bias</strong></td>
<td>2V / 5mA (2V / 20mA)</td>
<td>2V / 5mA (3V / 20mA)</td>
<td>2V / 18mA</td>
<td>1.8V / 3.3mA</td>
</tr>
<tr>
<td><strong>Features</strong></td>
<td></td>
<td></td>
<td>Constant Gain, NF: 1.5V – 3.0V</td>
<td>Voltage Regulator (1.7V ~ 3.3V) Enable / Shutdown ESD Protection</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>Lowest</td>
<td>Lower</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

Measured Data from CEL Eval Boards
2.4GHz Performance

- Excellent Low Noise Figure
  0.6dB, Ga=16dB (2V, 6mA)
  0.7dB, Ga=17dB (2V, 10mA)

- High Linearity, Output P1dB
  +12.5dBm (3V, 20mA)

- UHS3 SiGe HBT
  fmax : 110GHz process technology

- High Break down voltage
  Vceo: 4.3V min
  (absolute maximum ratings)
Low Noise SiGe Tr

Concept
- Advanced SiGe transistor with NEC’s High Voltage UHS2-HV process
- Low Noise, High Linearity @ 2GHz

Applications
- Low Noise Amplifier for Mobile Communications, etc.
- ISM Band LNA or Medium Power Stage

Performance (typical)
- Low Noise Figure: 0.7dB, 23dB Ga @ 1.0GHz (2V, 5mA) 0.8dB, 17dB Ga @ 2.0GHz 1.3dB, 10dB Ga @ 5.2GHz
- High Linearity, P1dB: +14dBm @ 1.0GHz (3V, 20mA) +13dBm @ 2.0GHz +12dBm @ 5.2GHz

Package M05
- Low Profile SOT-343 footprint: 2.0 x 2.1 x 0.59mm
Low Noise Si Transistor

NE662M04

Concept
- Low Noise, Low Current Si transistor made with NEC’s UHSO 25 GHz f<sub>t</sub> process
- High Gain at Low Voltage, Low Current

Applications
- Low Noise Amplifier for ISM Band, ZigBee, Mobile Communications, etc.
- Oscillator Applications for Communications

Performance (typical)
- Low Noise Figure: 1.0dB, 21dB Ga @ 1.0GHz (2V, 5mA)
  1.1dB, 16dB Ga @ 2.0GHz
  1.2dB, 14dB Ga @ 2.5GHz
- High Output P<sub>1dB</sub>: +12dBm @ 1.0GHz (2V, 20mA I<sub>CQ</sub>)
  +11dBm @ 2.0GHz

Package M04
- Low Profile SOT-343 footprint: 2.0 x 2.1 x 0.59mm
N-Channel HJ-FET LNA

NE3508M04

- Discrete GaAs FET Device
- LNA for 2.4GHz Applications
  - ZigBee, ISM Band, SDARS Antennas
- Operates from a Single Bias (Self-Bias Mode)
- Constant Gain with Voltage Bias 1.5V – 3.0V

Evaluation Board Test Results

\[ (V_{DD} = 3.0 \text{ V}, I_O = 29.1 \text{ mA}, f = 2.4 \text{ GHz}) \]

<table>
<thead>
<tr>
<th>Item</th>
<th>Symbol</th>
<th>Data</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise Figure</td>
<td>( NF )</td>
<td>0.74</td>
<td>dB</td>
</tr>
<tr>
<td>Associated Gain</td>
<td>( G_a )</td>
<td>14.8</td>
<td>dB</td>
</tr>
<tr>
<td>Return Loss (in)</td>
<td>( RL_{in} )</td>
<td>11.5</td>
<td>dB</td>
</tr>
<tr>
<td>Return Loss (out)</td>
<td>( RL_{out} )</td>
<td>18.8</td>
<td>dB</td>
</tr>
<tr>
<td>Output Power at 1 dB Compression Point</td>
<td>( P_{out} (1 \text{ dB}) )</td>
<td>15.9</td>
<td>dB</td>
</tr>
<tr>
<td>Output 3rd Order Distortion Intercept Point</td>
<td>( OIP_3 )</td>
<td>33.0</td>
<td>dBm</td>
</tr>
</tbody>
</table>

Notes 1. A substrate loss 0.11 dB is including in value of NF.
2. \( f = 2.4 \text{ GHz}, 1 \text{ MHz offset} \)
Process technology
- SiGe:C HBT Process (UHS4)

Application
- ZigBee, Bluetooth, GPS

Performance (Typ) @ 2.4GHz, 1.8V Vcc
- Low Supply Voltage, Low Noise, Low Current
  - Supply Voltage: 1.7V ~ 3.3V
  - NF: 1.3dB, Gain: 16.6dB
  - Input Return Loss (S11): 12dB
  - Output Return Loss (S22): 12dB
  - Icc = 3.3mA (@Vcc=1.8V, f=2.4GHz)
- Built-in Power Save function
  (V_pson: 1.0V ~ Vcc, V_psoff: 0 ~ 0.4V)
- Very robust Bandgap Regulator on chip
  (Small Vcc & Ta dependence)
- Included protection circuits for ESD
  - Sample tested to 1.4kV (HBM)

Package: 6pin L2MM
(1.5*1.1*0.55mm)

Pin Connections and Internal Block Diagram

Pb-Free Product
uPC8233TK Low Voltage Operation

Icc-Vcc Dependence (Vps=Vcc)

Operating Range
Vcc: 1.7V ~ 3.3V
uPC8233TK Tuning

LNA for 0.9, 1.5 & 2.4GHz

Narrow Band Tuned Performance

<table>
<thead>
<tr>
<th>Vcc = 1.8V</th>
<th>915 MHz</th>
<th>1.575GHz</th>
<th>2.4GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>NF (dB)</td>
<td>1.2</td>
<td>0.9</td>
<td>1.3</td>
</tr>
<tr>
<td>Gain (dB)</td>
<td>24.5</td>
<td>20.5</td>
<td>16.6</td>
</tr>
<tr>
<td>InR.L. (dB)</td>
<td>12</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>OutR.L.(dB)</td>
<td>14</td>
<td>16</td>
<td>12</td>
</tr>
</tbody>
</table>

Evaluation Board

<table>
<thead>
<tr>
<th></th>
<th>915 MHz</th>
<th>1.575GHz</th>
<th>2.4GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1 (nH)</td>
<td>24</td>
<td>10</td>
<td>4.7</td>
</tr>
<tr>
<td>C1 (pF)</td>
<td>33</td>
<td>22</td>
<td>56</td>
</tr>
<tr>
<td>C2 (pF)</td>
<td>2.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>L2 (nH)</td>
<td>68</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>L3 (nH)</td>
<td>15</td>
<td>6.8</td>
<td>6.8</td>
</tr>
<tr>
<td>C3 (pF)</td>
<td>22</td>
<td>18</td>
<td>0.5</td>
</tr>
<tr>
<td>C4 (pF)</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>C5 (pF)</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>R1 (ohm)</td>
<td>360</td>
<td>360</td>
<td>360</td>
</tr>
</tbody>
</table>

uPC8233TK Reference Circuit for L-S band
Thank You!

For Additional Information, Technical Support or Product Availability, Contact:

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Fax: (408) 988-0279
www.cel.com