

Features

- Low Noise Figure
- High Small Signal Gain
- Single +2.7 V Operation
- Power-up Control
- 50 Ω Output
- Unconditionally Stable

Benefits

- Low Power Consumption < 10 mW
- Very Small, PLLP6 Package (1.6 mm \times 2.0 mm)
- Few External Components

Electrostatic sensitive device.
Observe precautions for handling.

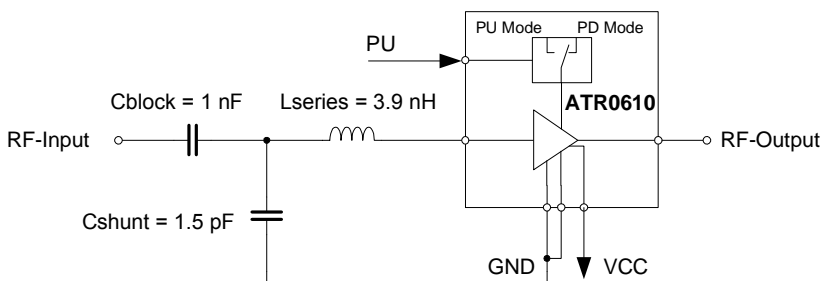


Description

The ATR0610 is a 2.7-V GPS low-noise amplifier IC designed for use in GPS applications. It uses a SiGe HBT die. The IC is 50- Ω matched on the output allowing the device to be used with minimal external circuitry. Its RF performance meets the requirements for products designed to the GPS standard.

The ATR0610 gives excellent RF performance with low current consumption resulting in longer battery life times. The package has a small 1.6 mm \times 2.0 mm footprint to allow use in compact GPS receiver design.

Figure 1. Block Diagram



2.7-V GPS Low-noise Amplifier

ATR0610

Preliminary



Pin Description

| Pin | Symbol | Function |
|-----|--------|---------------------------|
| 1 | VCC | Supply voltage |
| 2 | RF_OUT | Signal output |
| 3 | DC_GND | Ground |
| 4 | RF_IN | Input for received signal |
| 5 | RF_GND | Ground for RF stage |
| 6 | PU | Power up |

Absolute Maximum Ratings

| Parameters | Symbol | Value | Unit |
|-----------------------|-----------|--------------|------|
| Supply voltage | V_{CC} | -0.3 to +3.7 | V |
| Power-up Voltage | V_{PU} | -0.3 to +3.7 | V |
| Input power | P_{in} | -5 | dBm |
| Operating temperature | T_{op} | -40 to +85 | °C |
| Storage temperature | T_{stg} | -55 to +125 | °C |

Thermal Resistance

| Parameters | Symbol | Value | Unit |
|--------------------|----------|-------|------|
| Thermal resistance | R_{th} | TBD | K/W |

Electrical Characteristics

$V_{CC} = 2.7$ V, $V_{PU} = 1.8$ V, $f = 1575$ MHz, $T_{amb} = 25^{\circ}\text{C}$, $Z_{load} = 50 \Omega$ (see Figure 1)

Minimum/maximum limits are at +25°C ambient temperature, unless otherwise specified.

| No. | Parameters | Test Conditions | Pin | Symbol | Min. | Typ. | Max. | Unit | Type* |
|-----|---|--|-------|--------------|------|---------|------|------|-------|
| 1 | Operating frequency | | RF_IN | f | | 1575.42 | | MHz | D |
| 2 | Supply voltage | | VCC | V_{CC} | 2.7 | 3 | 3.3 | V | C |
| 3 | Operating current | RF ON ($V_{PU} = 1.8$ V) | VCC | I | 3 | 3.3 | 3.5 | mA | A |
| 4 | Power-down current | RF OFF ($V_{PU} = 0$ V) | VCC | I_{PD} | | 500 | | nA | A |
| 5 | Small signal gain | | | G | 15 | 16 | 17 | dB | A |
| 6 | Minimum noise figure | | | NF_{min} | | 1.5 | | dB | C |
| 7 | Noise figure | Using the proposed input matching (see Figure 1) | | NF | | 1.6 | | dB | C |
| 8 | Input referred 1 dB compression point | Caused by a DCS blocker at 1710 MHz | | I_{cp1} | | -9 | | dBm | A |
| 9 | Input 3 rd -order intercept point | f1 = 1750 MHz f2 = 1925 MHz | | IIP3 | | -1 | | dBm | C |
| 10 | Input 3 rd -order intercept point (inband) | f1 = 1575 MHz f2 = 1577 MHz | | $IIP3_{inb}$ | | -3 | | dBm | C |
| 11 | Input return loss | | | RL_{in} | 10 | 11 | | dB | C |
| 12 | Output return loss | | | RL_{out} | 11 | 12 | | dB | C |

*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

Electrical Characteristics (Continued)

$V_{CC} = 2.7\text{ V}$, $V_{PU} = 1.8\text{ V}$, $f = 1575\text{ MHz}$, $T_{amb} = 25^{\circ}\text{C}$, $Z_{load} = 50\ \Omega$ (see Figure 1)

Minimum/maximum limits are at +25°C ambient temperature, unless otherwise specified.

| No. | Parameters | Test Conditions | Pin | Symbol | Min. | Typ. | Max. | Unit | Type* |
|-----|-------------------|-----------------|-----|----------------|------|------|------|---------------|-------|
| 13 | Reverse isolation | | | $1/ S_{12} ^2$ | | 30 | | dB | C |
| 14 | Control voltage | Power-up mode | PU | $V_{PU,high}$ | 1.2 | 1.8 | 3.3 | V | C |
| 15 | Control current | Power-up mode | PU | $I_{PU,high}$ | 0 | 10 | 50 | μA | C |
| 16 | Control voltage | Power-down mode | PU | $V_{PU,low}$ | 0 | 0.2 | 0.4 | V | C |
| 17 | Control current | Power-down mode | PU | $I_{PU,low}$ | | | 0.7 | μA | C |

*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

Measurement Results

Matched Device
(see Figure 1)

Figure 2. Gain and Maximum Available Gain

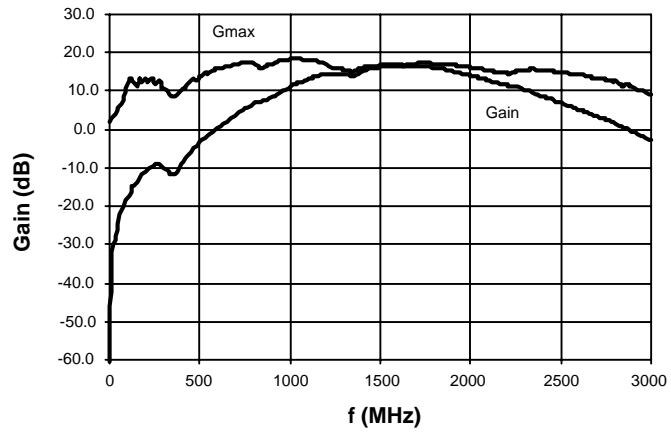


Figure 3. Input and Output Return Loss

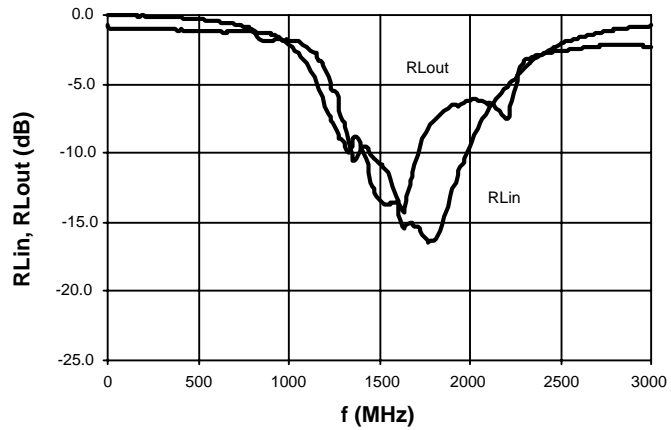


Figure 4. Reverse Transfer Function

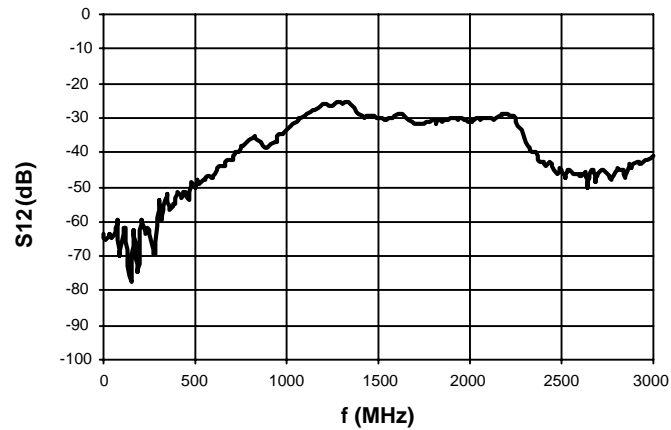


Figure 5. K Factor (=> Unconditional Stability)

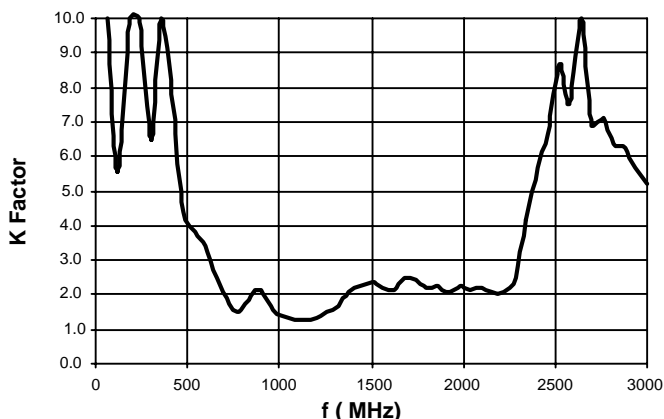


Table 1. Measured Scattering Parameters of Matched Device
(Given as Linear Magnitude and Phase in Degree)

| f /MHz | S ₁₁ | φ(S ₁₁) | S ₂₁ | φ(S ₂₁) | S ₁₂ | φ(S ₁₂) | S ₂₂ | φ(S ₂₂) | K Factor |
|--------|-----------------|---------------------|-----------------|---------------------|-----------------|---------------------|-----------------|---------------------|----------|
| 60 | 0.897 | -9.9 | 0.06 | -96.1702 | 0.0006 | 19.5 | 0.998 | -6.6 | 13.5 |
| 120 | 0.891 | -25.6 | 0.17 | -98.98544 | 0.0008 | 84.2 | 0.996 | -17.4 | 5.5 |
| 180 | 0.886 | -37.4 | 0.26 | -113.4846 | 0.0002 | 173.8 | 0.991 | -26.1 | 43.3 |
| 240 | 0.891 | -49.4 | 0.34 | -128.3148 | 0.0008 | -86.0 | 0.987 | -34.4 | 10.1 |
| 300 | 0.894 | -61.9 | 0.32 | -145.6032 | 0.0021 | -137.8 | 0.981 | -42.8 | 6.5 |
| 360 | 0.890 | -74.3 | 0.26 | -128.5304 | 0.0014 | 153.2 | 0.979 | -51.4 | 12.3 |
| 420 | 0.879 | -86.0 | 0.41 | -113.438 | 0.0022 | 149.7 | 0.973 | -60.1 | 7.4 |
| 480 | 0.876 | -97.1 | 0.62 | -117.7927 | 0.0037 | 147.3 | 0.965 | -69.3 | 4.4 |
| 540 | 0.872 | -108.2 | 0.83 | -125.7797 | 0.0039 | 143.4 | 0.958 | -78.0 | 3.8 |
| 600 | 0.869 | -118.8 | 1.07 | -135.3626 | 0.0043 | 142.5 | 0.948 | -87.1 | 3.4 |
| 660 | 0.872 | -129.8 | 1.34 | -144.9783 | 0.0063 | 130.7 | 0.935 | -96.9 | 2.5 |
| 720 | 0.874 | -140.7 | 1.66 | -155.2931 | 0.0101 | 127.3 | 0.920 | -106.6 | 1.7 |
| 780 | 0.878 | -153.0 | 2.04 | -168.018 | 0.0144 | 108.8 | 0.893 | -116.9 | 1.5 |
| 840 | 0.813 | -165.3 | 2.30 | 177.8467 | 0.0152 | 73.6 | 0.863 | -126.3 | 2.0 |
| 900 | 0.806 | -172.6 | 2.64 | 169.357 | 0.0126 | 71.9 | 0.853 | -137.2 | 2.1 |
| 960 | 0.813 | 176.5 | 3.17 | 157.1773 | 0.0185 | 79.4 | 0.817 | -149.8 | 1.6 |
| 1020 | 0.809 | 164.4 | 3.78 | 143.6133 | 0.0237 | 67.9 | 0.767 | -163.0 | 1.4 |
| 1080 | 0.785 | 150.1 | 4.34 | 128.2928 | 0.0318 | 51.1 | 0.693 | -176.6 | 1.3 |
| 1140 | 0.732 | 135.5 | 4.93 | 111.4632 | 0.0399 | 35.3 | 0.598 | 168.3 | 1.3 |
| 1200 | 0.637 | 118.7 | 5.30 | 92.48291 | 0.0491 | 11.0 | 0.466 | 155.8 | 1.3 |
| 1260 | 0.522 | 107.6 | 5.32 | 76.71066 | 0.0494 | -10.0 | 0.381 | 147.9 | 1.5 |
| 1320 | 0.378 | 98.0 | 5.24 | 63.20023 | 0.0517 | -36.7 | 0.325 | 141.9 | 1.7 |
| 1380 | 0.311 | 108.3 | 5.33 | 56.22391 | 0.0385 | -63.8 | 0.358 | 125.1 | 2.1 |
| 1440 | 0.325 | 97.5 | 6.14 | 41.04218 | 0.0326 | -62.8 | 0.270 | 88.5 | 2.3 |
| 1500 | 0.287 | 88.9 | 6.51 | 25.58716 | 0.0307 | -74.9 | 0.212 | 52.2 | 2.4 |

Table 1. Measured Scattering Parameters of Matched Device
(Given as Linear Magnitude and Phase in Degree) (Continued)

| f /MHz | S ₁₁ | ∠(S ₁₁) | S ₂₁ | ∠(S ₂₁) | S ₁₂ | ∠(S ₁₂) | S ₂₂ | ∠(S ₂₂) | K Factor |
|--------|-----------------|---------------------|-----------------|---------------------|-----------------|---------------------|-----------------|---------------------|----------|
| 1560 | 0.257 | 73.3 | 6.77 | 8.313904 | 0.0320 | -76.5 | 0.207 | -1.0 | 2.2 |
| 1620 | 0.180 | 59.1 | 6.58 | -8.583069 | 0.0355 | -93.7 | 0.202 | -46.0 | 2.1 |
| 1680 | 0.175 | 46.3 | 6.79 | -22.98477 | 0.0281 | -107.7 | 0.268 | -62.3 | 2.5 |
| 1740 | 0.160 | 3.9 | 6.78 | -40.46539 | 0.0263 | -103.6 | 0.358 | -81.5 | 2.4 |
| 1800 | 0.152 | -43.9 | 6.33 | -57.3143 | 0.0297 | -112.5 | 0.411 | -101.3 | 2.2 |
| 1860 | 0.187 | -77.9 | 5.95 | -73.04535 | 0.0288 | -121.8 | 0.453 | -116.8 | 2.2 |
| 1920 | 0.249 | -104.8 | 5.58 | -87.41135 | 0.0310 | -132.7 | 0.471 | -129.8 | 2.1 |
| 1980 | 0.314 | -122.7 | 5.15 | -100.7899 | 0.0285 | -142.7 | 0.487 | -139.2 | 2.3 |
| 2040 | 0.389 | -137.6 | 4.71 | -114.63 | 0.0307 | -154.3 | 0.492 | -150.3 | 2.1 |
| 2100 | 0.450 | -151.0 | 4.33 | -127.6309 | 0.0305 | -171.1 | 0.476 | -156.8 | 2.2 |
| 2160 | 0.514 | -162.2 | 3.99 | -138.8933 | 0.0328 | 175.1 | 0.452 | -162.0 | 2.1 |
| 2220 | 0.564 | -172.4 | 3.71 | -151.1952 | 0.0333 | 148.3 | 0.443 | -152.8 | 2.1 |
| 2280 | 0.621 | 179.3 | 3.45 | -166.5967 | 0.0205 | 110.4 | 0.645 | -158.2 | 2.5 |
| 2340 | 0.678 | 169.7 | 3.08 | -178.6954 | 0.0100 | 118.3 | 0.708 | -173.7 | 4.1 |
| 2400 | 0.722 | 160.6 | 2.66 | 170.4748 | 0.0071 | 129.9 | 0.722 | 175.9 | 5.7 |
| 2460 | 0.762 | 152.2 | 2.39 | 158.4146 | 0.0056 | 136.8 | 0.738 | 167.1 | 6.7 |
| 2520 | 0.793 | 144.0 | 2.14 | 148.5269 | 0.0042 | 129.5 | 0.742 | 158.8 | 8.7 |
| 2580 | 0.821 | 136.5 | 1.87 | 139.0457 | 0.0047 | 134.1 | 0.750 | 151.3 | 7.5 |
| 2640 | 0.839 | 129.4 | 1.65 | 127.6694 | 0.0032 | 158.1 | 0.762 | 143.8 | 11.3 |
| 2700 | 0.857 | 122.3 | 1.50 | 118.4024 | 0.0048 | 168.3 | 0.768 | 136.4 | 6.9 |
| 2760 | 0.876 | 115.8 | 1.30 | 109.0173 | 0.0047 | 173.3 | 0.774 | 129.3 | 7.1 |
| 2820 | 0.886 | 109.5 | 1.13 | 98.04062 | 0.0056 | -171.8 | 0.775 | 121.4 | 6.3 |
| 2880 | 0.900 | 103.2 | 0.99 | 88.75305 | 0.0058 | -173.3 | 0.775 | 113.9 | 6.2 |
| 2940 | 0.908 | 97.4 | 0.84 | 80.06287 | 0.0069 | 175.4 | 0.775 | 106.6 | 5.6 |
| 3000 | 0.914 | 91.3 | 0.71 | 69.79065 | 0.0086 | 167.6 | 0.761 | 98.8 | 5.2 |

Figure 6. Gain versus Blocker at 1710 MHz (Compression)

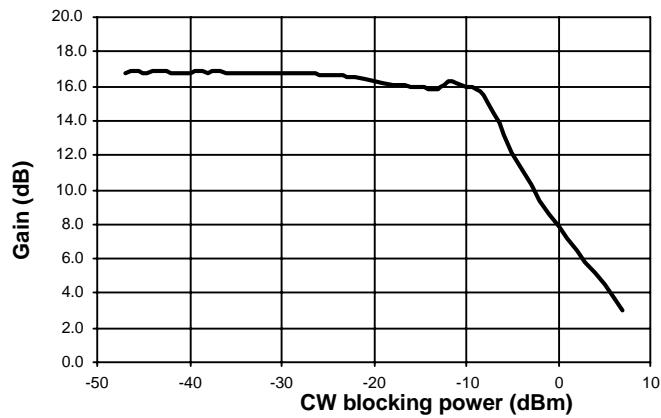


Figure 7. Out of Band Intermodulation Product 3rd Order (IP3)

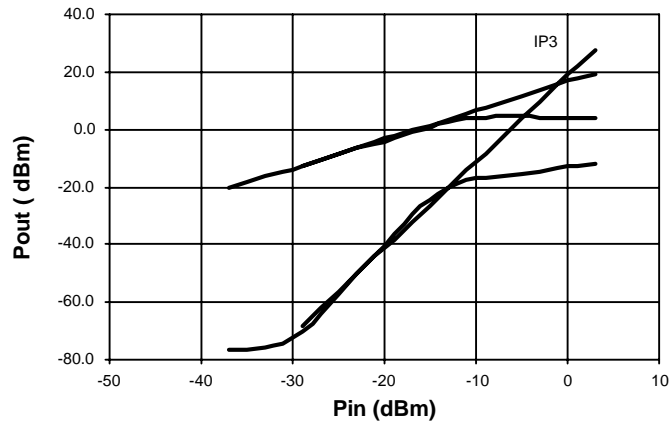


Figure 8. Inband Intermodulation Product 3rd Order (Inband IP3)

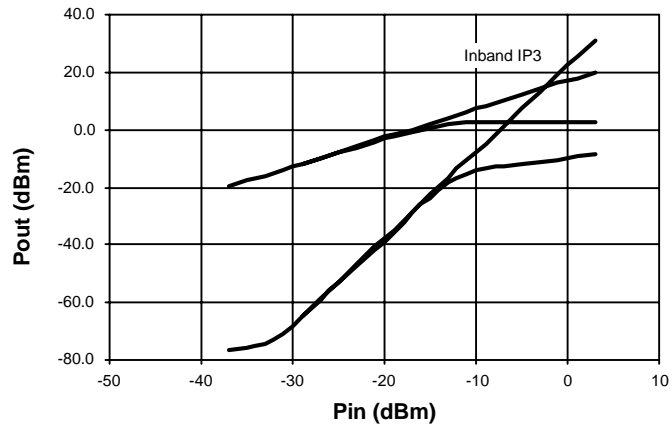


Figure 9. Noise Figure without any De-embedding

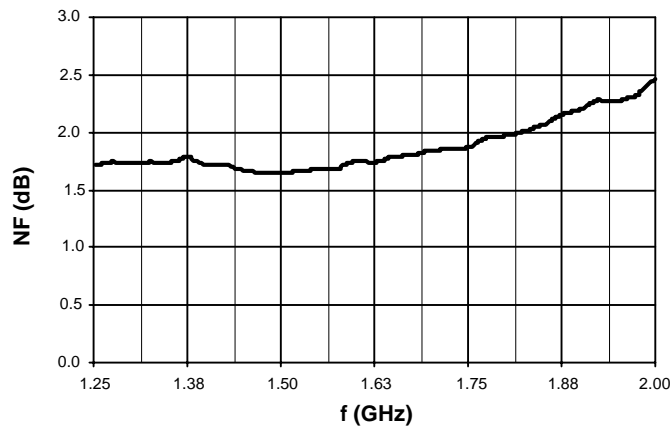
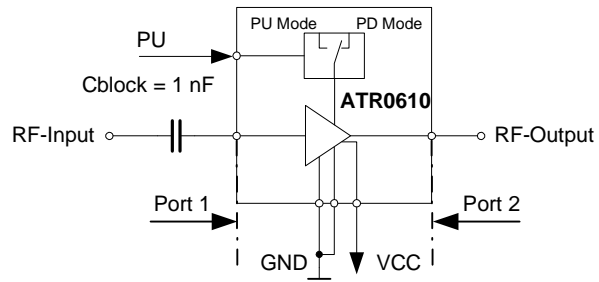


Figure 10. Reference Planes of Unmatched Device



Unmatched Device

Table 2. Measured Scattering Parameters of Unmatched Device (De-embedded)
(Given as Linear Magnitude and Phase in Degree)

| f/MHz | S11 | φ(S11) | S21 | φ(S21) | S12 | φ(S12) | S22 | φ(S22) |
|-------|-------|--------|------|--------|-------|--------|-------|--------|
| 1.400 | 0.725 | -116.0 | 6.04 | 132.8 | 0.028 | 63.1 | 0.400 | 104.5 |
| 1.425 | 0.712 | -117.7 | 6.12 | 127.7 | 0.030 | 58.2 | 0.366 | 94.5 |
| 1.450 | 0.698 | -119.3 | 6.17 | 122.6 | 0.031 | 53.0 | 0.332 | 83.6 |
| 1.475 | 0.682 | -120.6 | 6.19 | 117.6 | 0.032 | 47.7 | 0.303 | 72.2 |
| 1.500 | 0.666 | -122.0 | 6.18 | 112.7 | 0.033 | 42.0 | 0.278 | 60.2 |
| 1.525 | 0.647 | -123.1 | 6.16 | 108.1 | 0.033 | 35.9 | 0.258 | 47.4 |
| 1.550 | 0.630 | -123.9 | 6.10 | 103.8 | 0.034 | 29.5 | 0.244 | 35.0 |
| 1.575 | 0.610 | -124.4 | 6.05 | 99.6 | 0.034 | 22.5 | 0.240 | 22.5 |
| 1.600 | 0.592 | -124.6 | 5.98 | 95.8 | 0.034 | 15.9 | 0.240 | 10.8 |
| 1.625 | 0.573 | -124.2 | 5.93 | 92.4 | 0.034 | 7.8 | 0.249 | 1.5 |
| 1.650 | 0.558 | -123.3 | 5.92 | 89.4 | 0.032 | -1.0 | 0.276 | -7.1 |
| 1.675 | 0.552 | -121.7 | 5.99 | 86.0 | 0.029 | -9.0 | 0.315 | -16.6 |
| 1.700 | 0.556 | -120.5 | 6.05 | 82.0 | 0.026 | -15.3 | 0.360 | -27.3 |
| 1.725 | 0.565 | -120.0 | 6.10 | 77.5 | 0.022 | -18.7 | 0.404 | -38.2 |
| 1.750 | 0.573 | -120.1 | 6.10 | 72.9 | 0.020 | -20.0 | 0.443 | -48.6 |

Figure 11. Minimum Noise Figure NF_{min} (De-embedded)

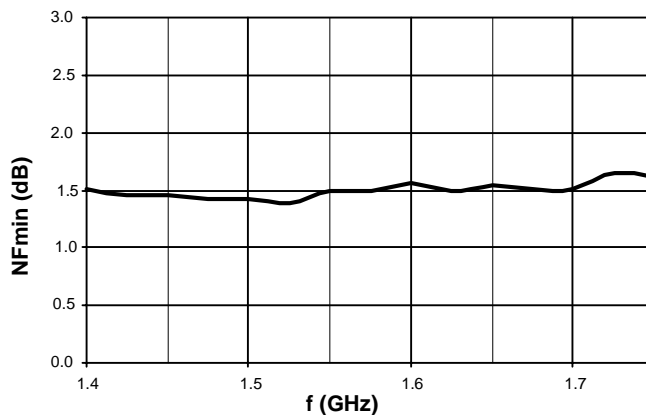
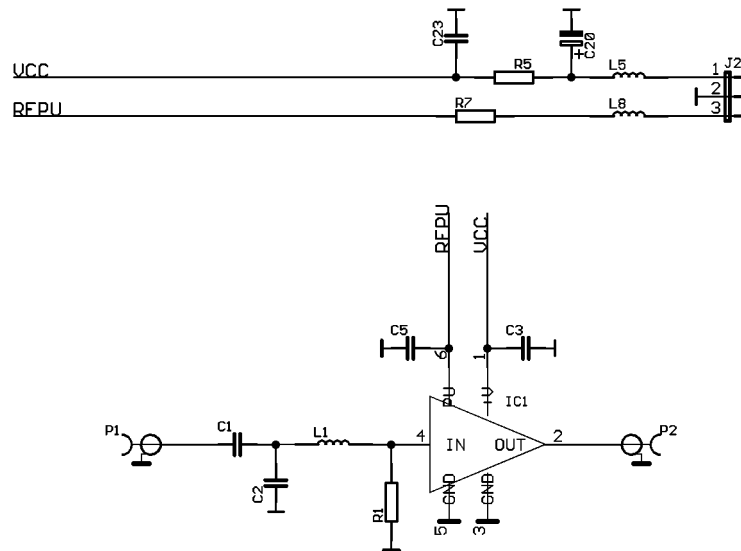


Table 3. Raw Noise Data of Unmatched Device (de-embedded)

| f/GHz | NFmin/dB | $ \Gamma_{opt} $ | $\phi(\Gamma_{opt})$ | Rn/ Ω |
|-------|----------|------------------|----------------------|--------------|
| 1.400 | 1.51 | 0.31 | 98.07 | 8.89 |
| 1.425 | 1.46 | 0.31 | 98.55 | 8.71 |
| 1.450 | 1.45 | 0.31 | 100.00 | 9.30 |
| 1.475 | 1.43 | 0.31 | 100.16 | 9.13 |
| 1.500 | 1.43 | 0.31 | 101.78 | 8.70 |
| 1.525 | 1.38 | 0.32 | 103.08 | 9.15 |
| 1.550 | 1.49 | 0.31 | 104.16 | 9.41 |
| 1.575 | 1.49 | 0.31 | 106.49 | 8.78 |
| 1.600 | 1.57 | 0.28 | 109.84 | 9.05 |
| 1.625 | 1.50 | 0.30 | 110.74 | 8.22 |
| 1.650 | 1.54 | 0.31 | 112.12 | 8.41 |
| 1.675 | 1.52 | 0.31 | 113.20 | 8.61 |
| 1.700 | 1.52 | 0.31 | 113.33 | 8.40 |
| 1.725 | 1.65 | 0.28 | 116.76 | 8.61 |
| 1.700 | 1.52 | 0.31 | 113.33 | 8.40 |
| 1.725 | 1.65 | 0.28 | 116.76 | 8.61 |
| 1.750 | 1.62 | 0.31 | 115.03 | 8.24 |

Figure 12. Schematic of Application Board

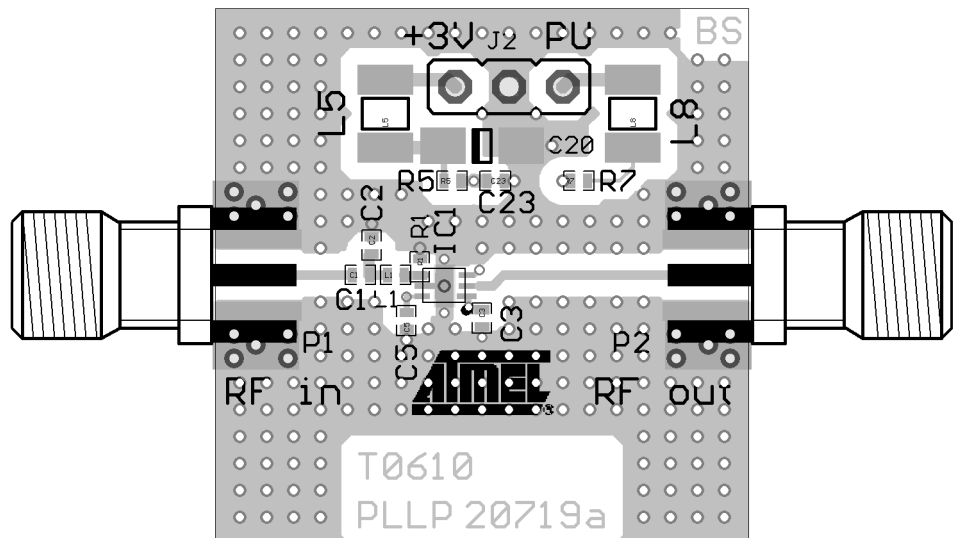


Bill of Materials of Demo Board

| Component | Reference | Vendor | Part Number/Remark | Value | Size/Package ⁽¹⁾ |
|-----------|-----------|------------------|--------------------|--------|-----------------------------|
| C1 | | | | 1 nF | 0402 |
| C2 | | | NPO | 1.5 pF | 0402 |
| C3, C5 | | | | nc | |
| C20 | | | | 10 uF | 3216 |
| C23 | | | | 100 nF | 0402 |
| L1 | | TOKO | LL1005-FH3N9 | 3.9 nH | 0402 |
| L5, L8 | | Würth Elektronik | WE74476401 | | 1210 |
| R1 | | | | nc | |
| R5, R7 | | | | 1Ω | 0402 |

Note: 1. Other sizes are possible.

Figure 13. Layout of Demo Board

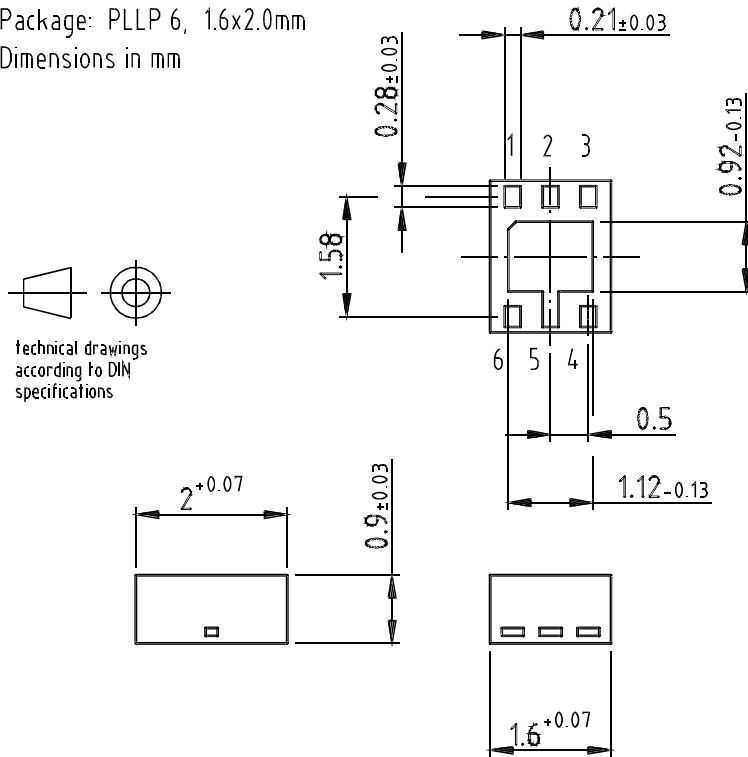


Ordering Information

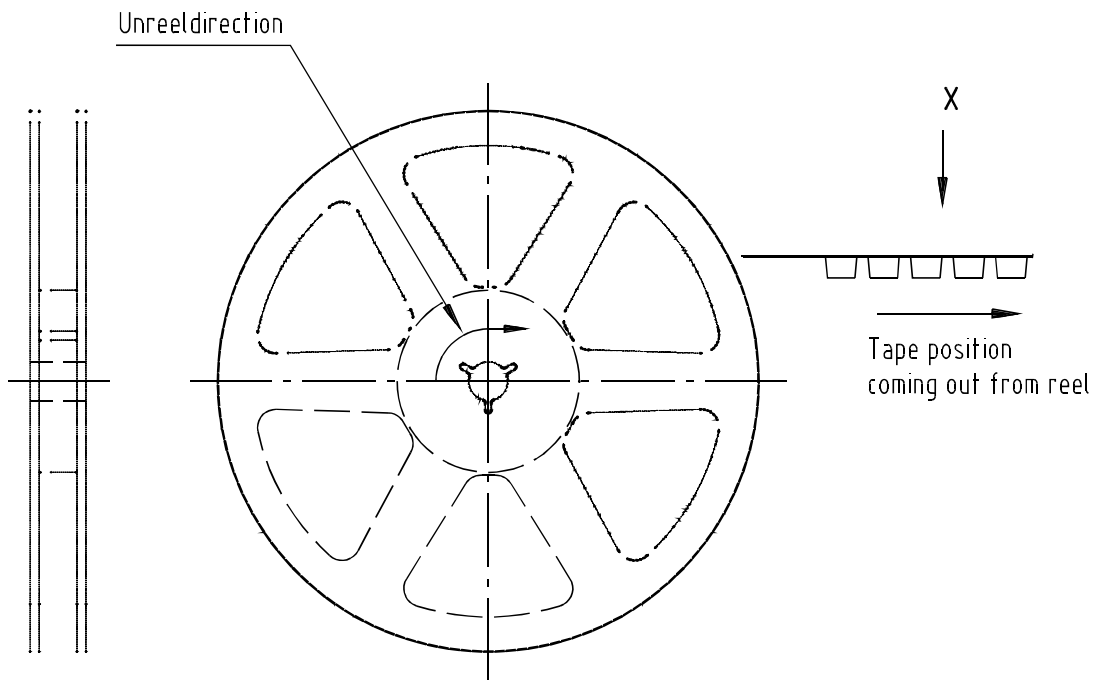
| Extended Type Number | Package | Remarks |
|----------------------|---------|------------------------------------|
| ATR0610-PQQ | PLL6 | Area 1.6 mm × 2.0 mm, 0.5 mm pitch |

Package Information

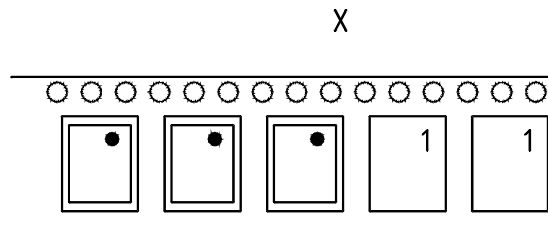
Package: PLL6, 1.6x2.0mm
Dimensions in mm



Drawing-No.: 6.549-5033.01-4
Issue: 1; 25.07.02



technical drawings according to DIN specifications



Drawing-No.: 9.800-5081.01-4.01-4
 Issue: 1; 24.10.02



Atmel Headquarters

Corporate Headquarters
2325 Orchard Parkway
San Jose, CA 95131
TEL 1(408) 441-0311
FAX 1(408) 487-2600

Europe

Atmel Sarl
Route des Arsenaux 41
Case Postale 80
CH-1705 Fribourg
Switzerland
TEL (41) 26-426-5555
FAX (41) 26-426-5500

Asia

Room 1219
Chinachem Golden Plaza
77 Mody Road Tsimhatsui
East Kowloon
Hong Kong
TEL (852) 2721-9778
FAX (852) 2722-1369

Japan

9F, Tonetsu Shinkawa Bldg.
1-24-8 Shinkawa
Chuo-ku, Tokyo 104-0033
Japan
TEL (81) 3-3523-3551
FAX (81) 3-3523-7581

Atmel Operations

Memory

2325 Orchard Parkway
San Jose, CA 95131
TEL 1(408) 441-0311
FAX 1(408) 436-4314

Microcontrollers

2325 Orchard Parkway
San Jose, CA 95131
TEL 1(408) 441-0311
FAX 1(408) 436-4314

La Chantrerie
BP 70602
44306 Nantes Cedex 3, France
TEL (33) 2-40-18-18-18
FAX (33) 2-40-18-19-60

ASIC/ASSP/Smart Cards

Zone Industrielle
13106 Rousset Cedex, France
TEL (33) 4-42-53-60-00
FAX (33) 4-42-53-60-01

1150 East Cheyenne Mtn. Blvd.
Colorado Springs, CO 80906
TEL 1(719) 576-3300
FAX 1(719) 540-1759

Scottish Enterprise Technology Park
Maxwell Building
East Kilbride G75 0QR, Scotland
TEL (44) 1355-803-000
FAX (44) 1355-242-743

RF/Automotive

Theresienstrasse 2
Postfach 3535
74025 Heilbronn, Germany
TEL (49) 71-31-67-0
FAX (49) 71-31-67-2340

1150 East Cheyenne Mtn. Blvd.
Colorado Springs, CO 80906
TEL 1(719) 576-3300
FAX 1(719) 540-1759

Biometrics/Imaging/Hi-Rel MPU/ High Speed Converters/RF Datacom

Avenue de Rochepleine
BP 123
38521 Saint-Egreve Cedex, France
TEL (33) 4-76-58-30-00
FAX (33) 4-76-58-34-80

e-mail

literature@atmel.com

Web Site

<http://www.atmel.com>

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