

## Features

- Low Noise Figure
- High Small Signal Gain
- Single +2.7 V Operation
- Power-up Control
- 50  $\Omega$  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.

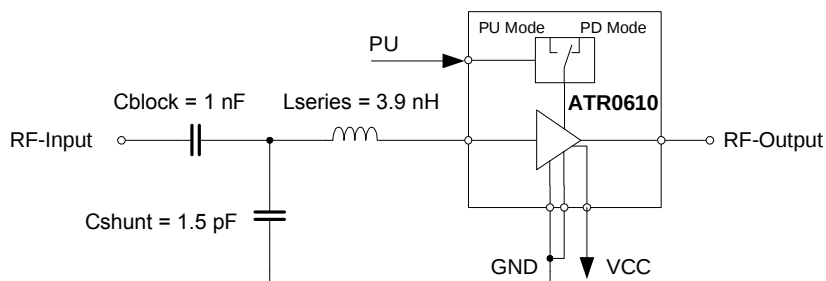


## Description

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- $\Omega$  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 <sup>rd</sup> -order intercept point          | f1 = 1750 MHz<br>f2 = 1925 MHz                   |       | IIP3         |      | -1      |      | dBm  | C     |
| 10  | Input 3 <sup>rd</sup> -order intercept point (inband) | f1 = 1575 MHz<br>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  $+25^{\circ}\text{C}$  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   | $\mu\text{A}$ | 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  | $\mu\text{A}$ | 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

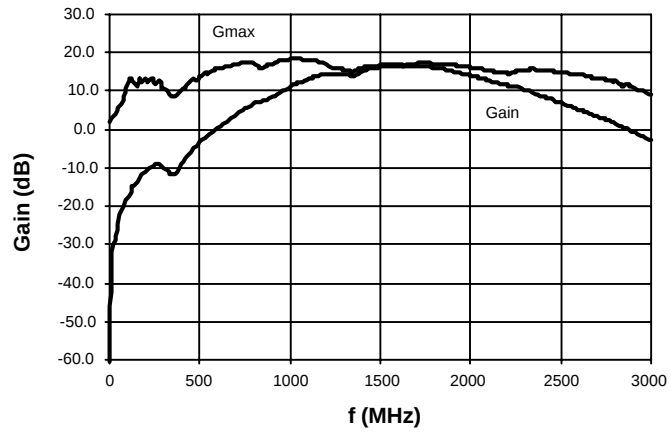


Figure 3. Input and Output Return Loss

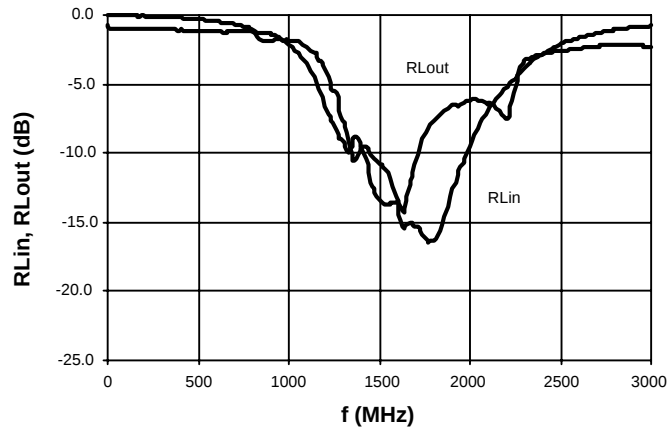


Figure 4. Reverse Transfer Function

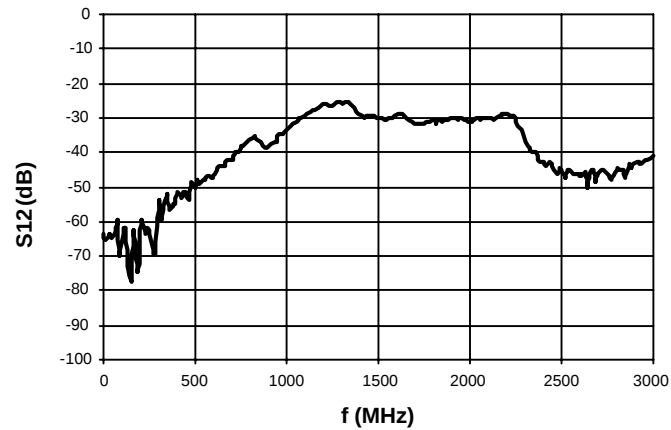


Figure 5. K Factor (=> Unconditional Stability)

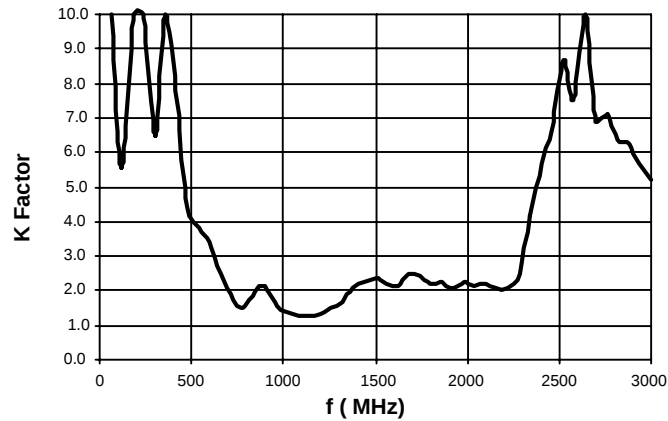


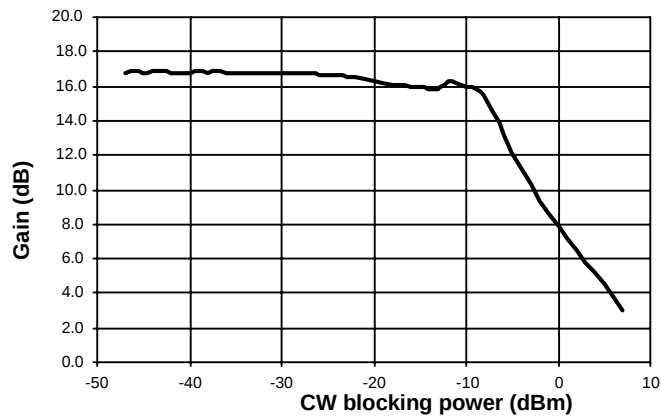
Table 1. Measured Scattering Parameters of Matched Device  
(Given as Linear Magnitude and Phase in Degree)

| f /MHz | $ S_{11} $ | $\phi(S_{11})$ | $ S_{21} $ | $\phi(S_{21})$ | $ S_{12} $ | $\phi(S_{12})$ | $ S_{22} $ | $\phi(S_{22})$ | 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      |

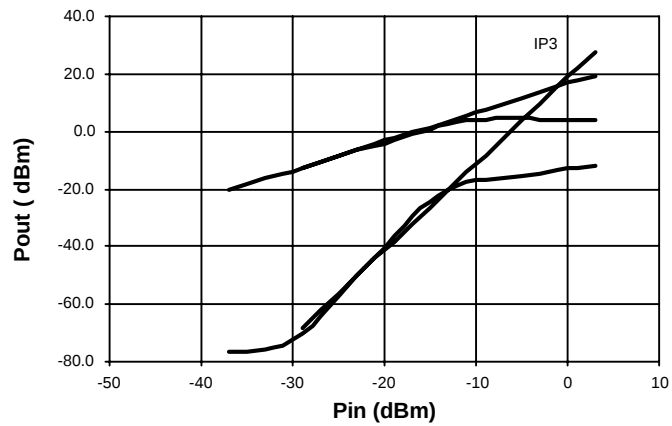
**Table 1.** Measured Scattering Parameters of Matched Device  
(Given as Linear Magnitude and Phase in Degree) (Continued)

| f /MHz | S <sub>11</sub> | φ(S <sub>11</sub> ) | S <sub>21</sub> | φ(S <sub>21</sub> ) | S <sub>12</sub> | φ(S <sub>12</sub> ) | S <sub>22</sub> | φ(S <sub>22</sub> ) | 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      |

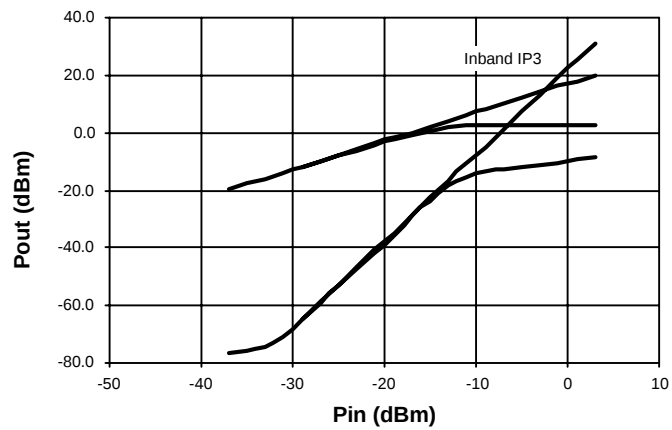
**Figure 6.** Gain versus Blocker at 1710 MHz (Compression)



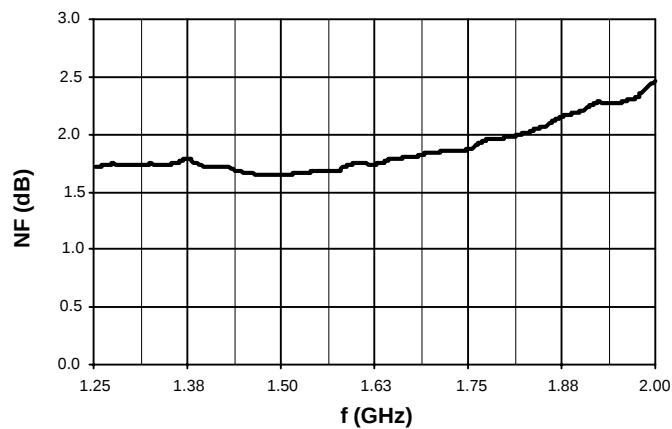
**Figure 7.** Out of Band Intermodulation Product 3<sup>rd</sup> Order (IP3)



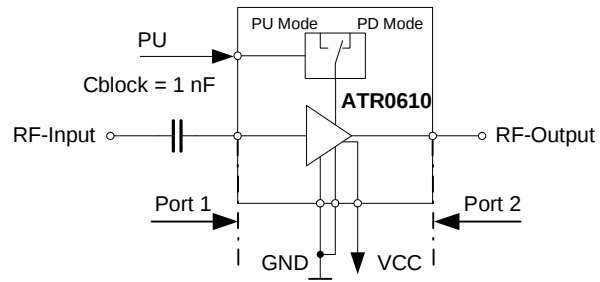
**Figure 8.** Inband Intermodulation Product 3<sup>rd</sup> Order (Inband IP3)



**Figure 9.** Noise Figure without any De-embedding



**Figure 10.** Reference Planes of Unmatched Device

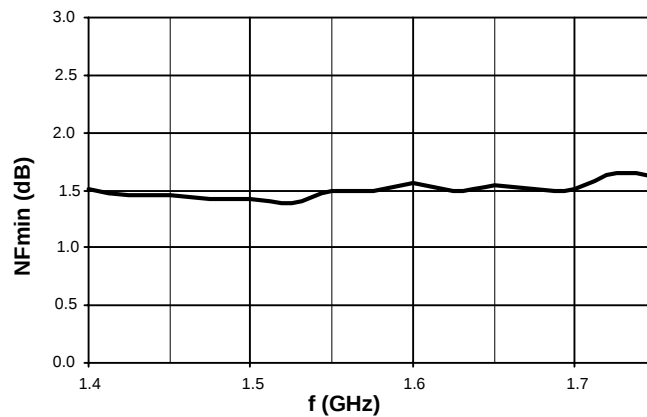


## Unmatched Device

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

| f/MHz | S11   | $\phi(S11)$ | S21  | $\phi(S21)$ | S12   | $\phi(S12)$ | S22   | $\phi(S22)$ |
|-------|-------|-------------|------|-------------|-------|-------------|-------|-------------|
| 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       |

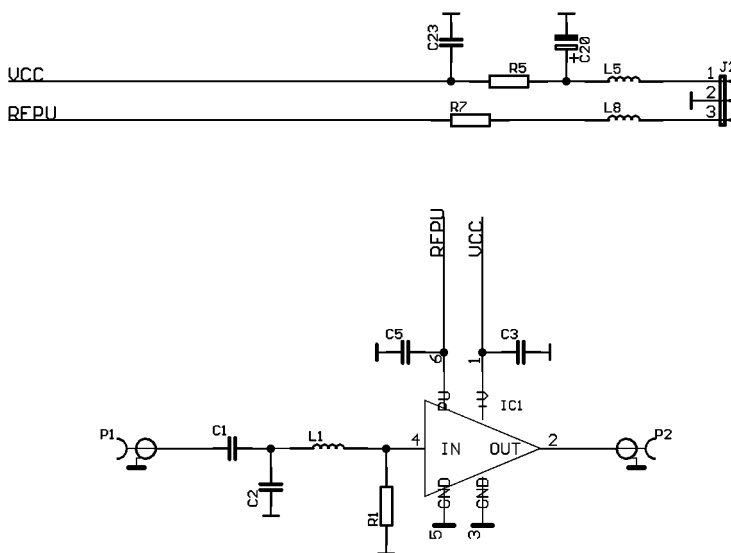
**Figure 11.** Minimum Noise Figure  $NF_{min}$  (De-embedded)



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

| f/GHz | NFmin/dB | $ \Gamma_{opt} $ | $\phi(\Gamma_{opt})$ | Rn/ $\Omega$ |
|-------|----------|------------------|----------------------|--------------|
| 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

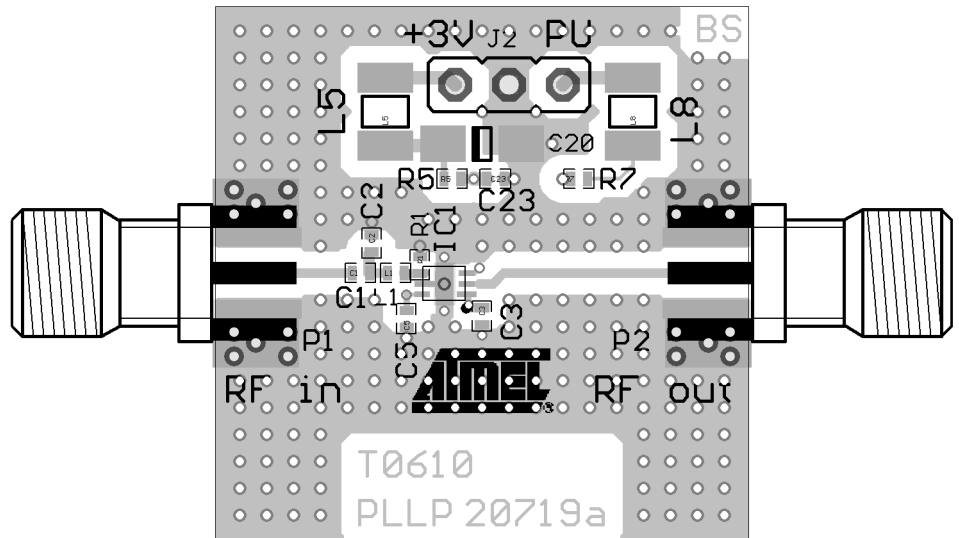


## Bill of Materials of Demo Board

| Component | Reference | Vendor           | Part Number/Remark | Value  | Size/Package <sup>(1)</sup> |
|-----------|-----------|------------------|--------------------|--------|-----------------------------|
| 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

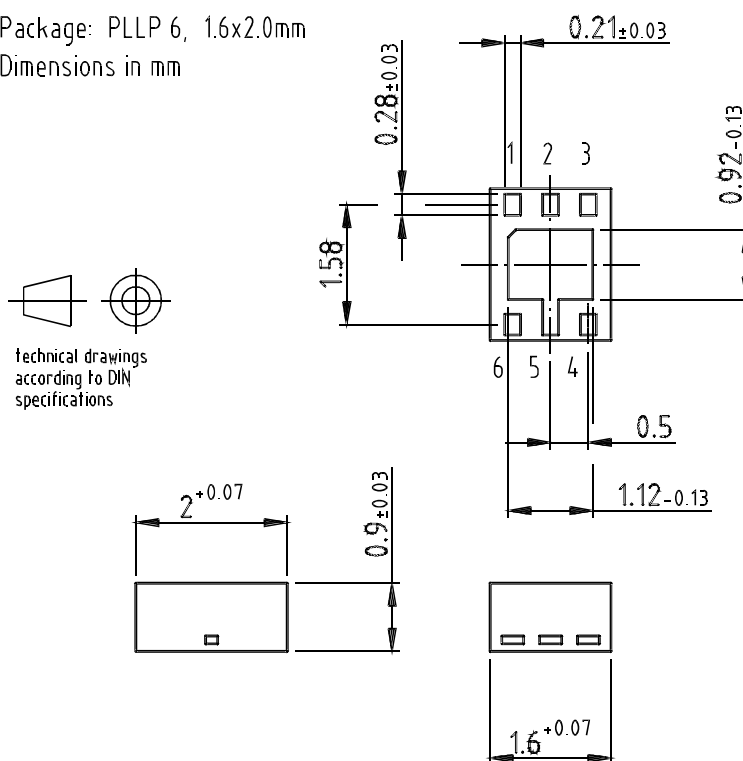


## Ordering Information

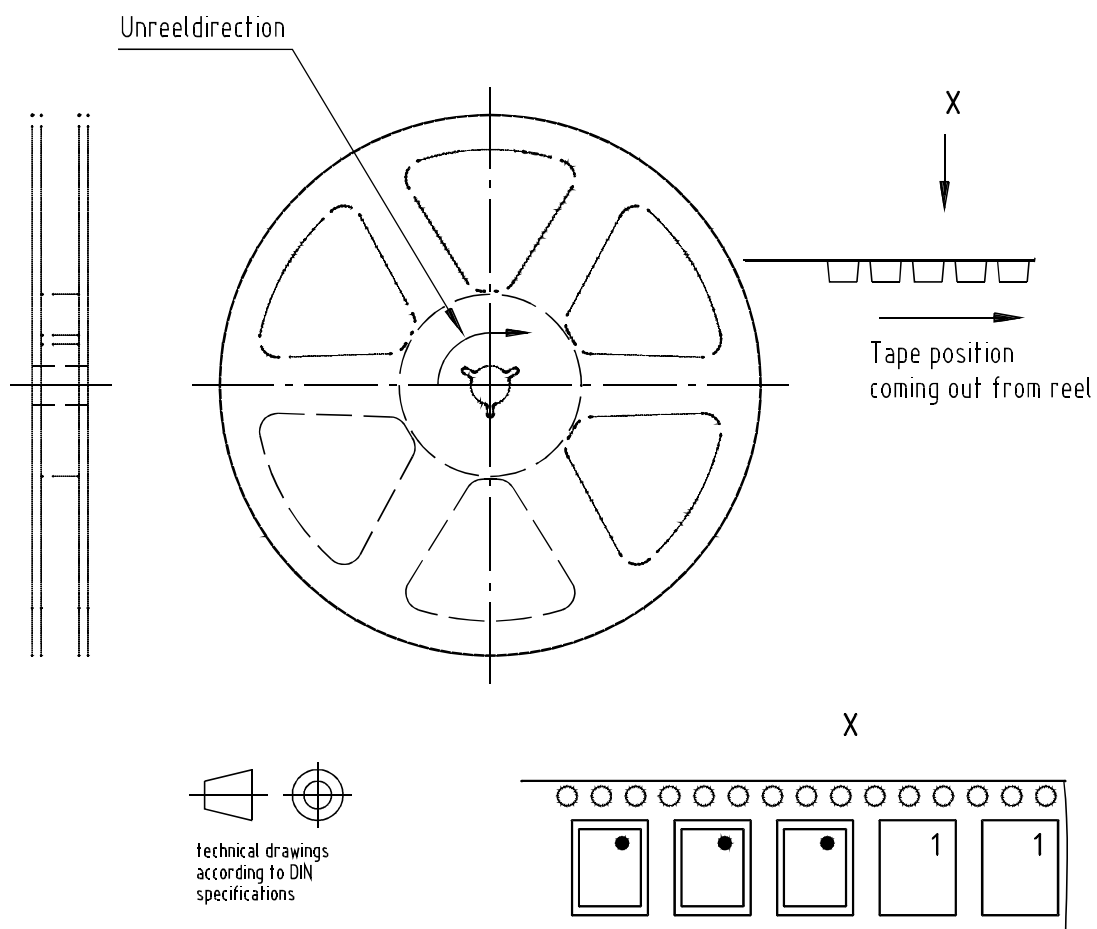
| Extended Type Number | Package | Remarks                            |
|----------------------|---------|------------------------------------|
| ATR0610-PQQ          | PLL6    | Area 1.6 mm × 2.0 mm, 0.5 mm pitch |

## Package Information

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



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



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



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