

## 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.

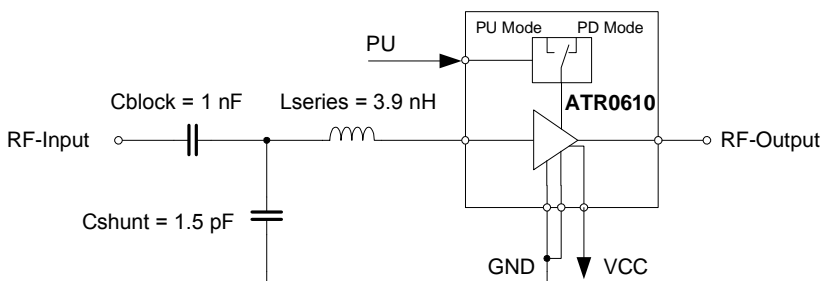


## Description

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

$V_{CC} = 2.7\text{ V}$ ,  $V_{PU} = 1.8\text{ V}$ ,  $f = 1575\text{ MHz}$ ,  $T_{amb} = 25^\circ\text{C}$ ,  $Z_{load} = 50\ \Omega$  (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*
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 ( $V_{PU} = 1.8\text{ V}$ )	VCC	I	3	3.3	3.5	mA	A
4	Power-down current	RF OFF ( $V_{PU} = 0\text{ V}$ )	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 f2 = 1925 MHz		IIP3		-1		dBm	C
10	Input 3 <sup>rd</sup> -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	$\mu\text{A}$	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

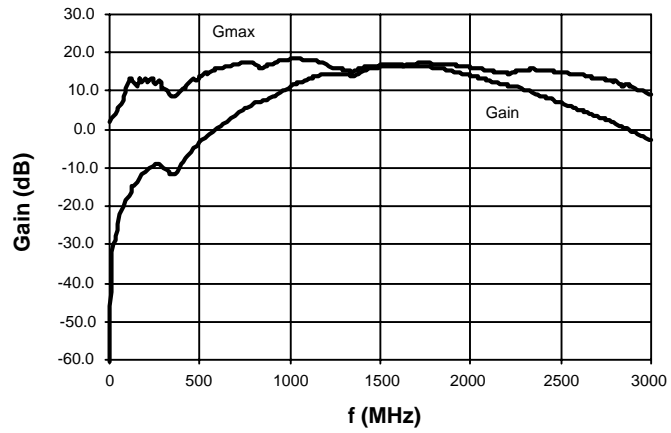


Figure 3. Input and Output Return Loss

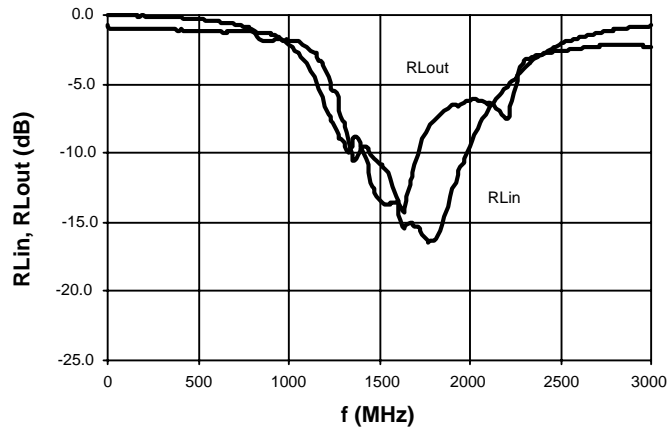


Figure 4. Reverse Transfer Function

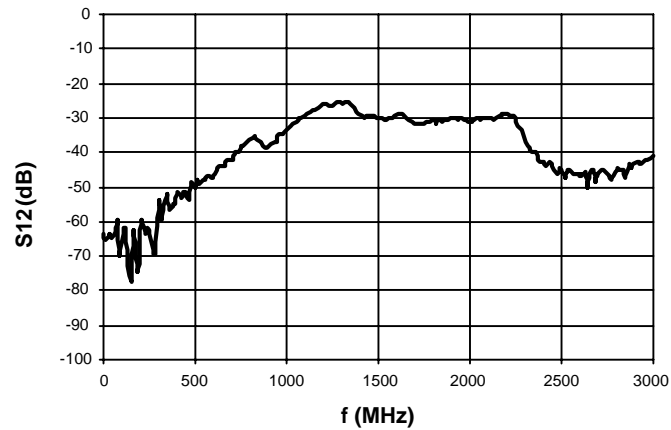


Figure 5. K Factor ( => Unconditional Stability)

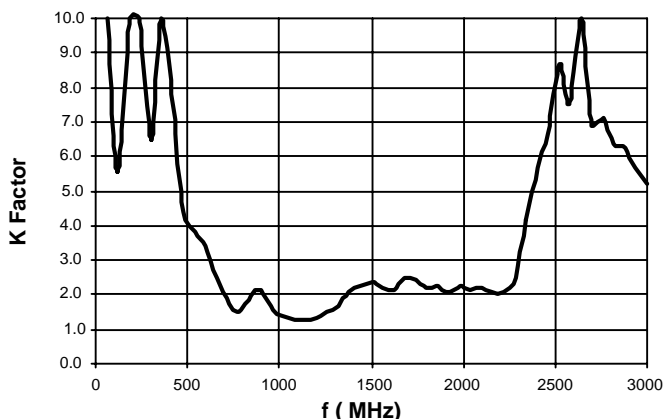


Table 1. Measured Scattering Parameters of Matched Device  
(Given as Linear Magnitude and Phase in Degree)

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

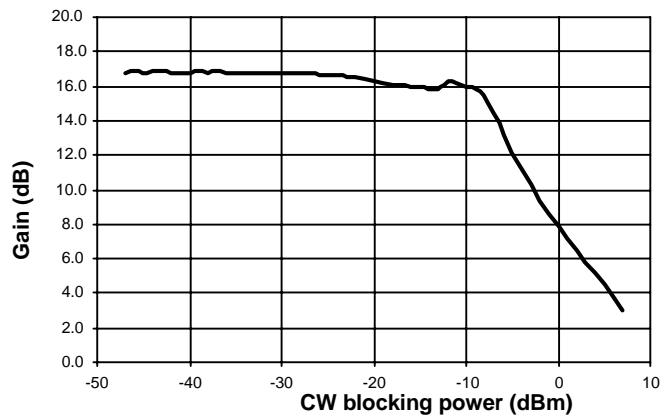


Figure 7. Out of Band Intermodulation Product 3<sup>rd</sup> Order (IP3)

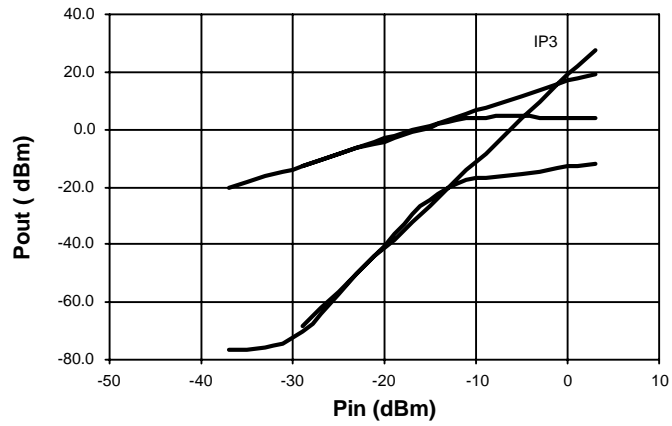


Figure 8. Inband Intermodulation Product 3<sup>rd</sup> Order (Inband IP3)

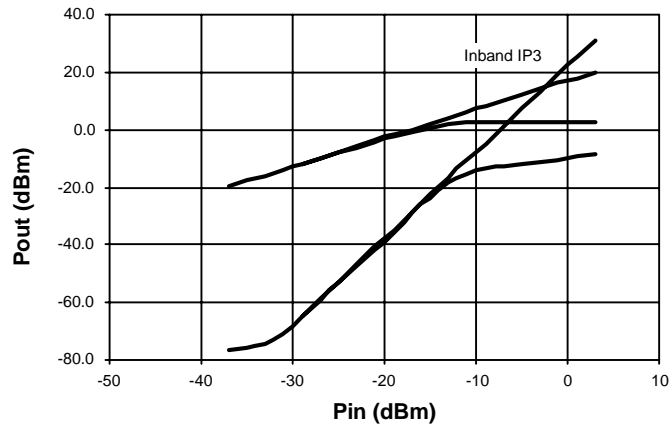
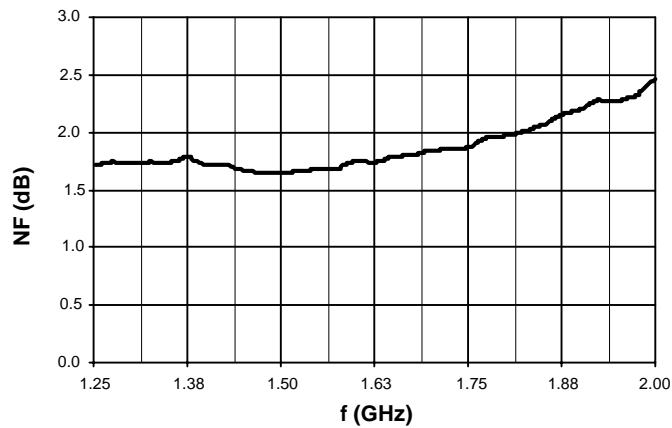
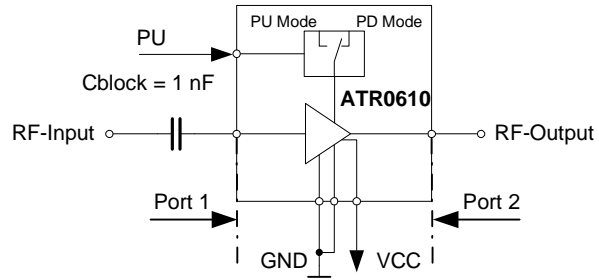


Figure 9. Noise Figure without any De-embedding



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

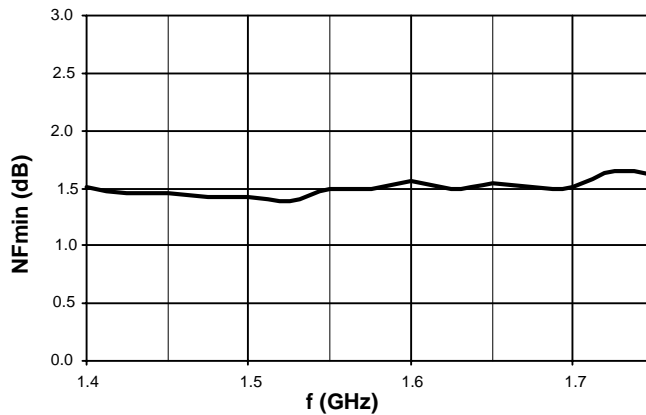


## Unmatched Device

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

f/MHz	S11	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)

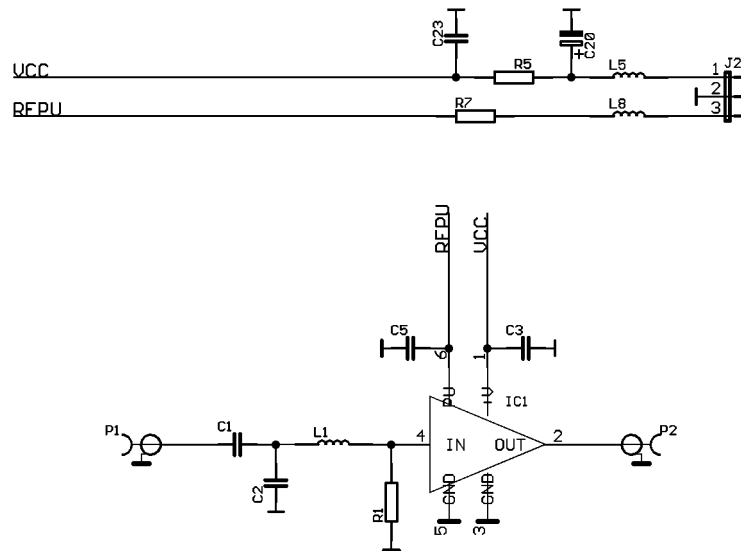




**Table 3.** Raw Noise Data of Unmatched Device (de-embedded)

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

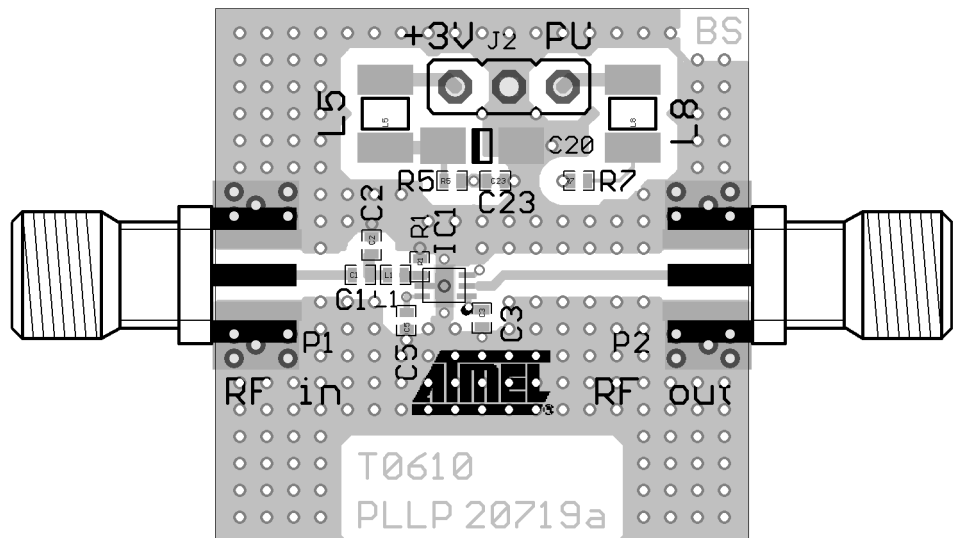


## Bill of Materials of Demo Board

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

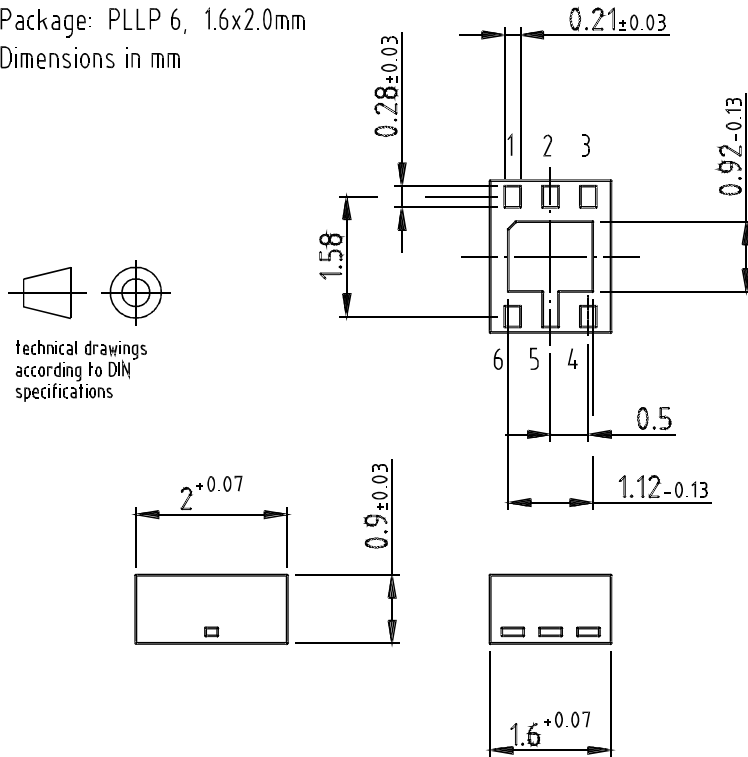


### Ordering Information

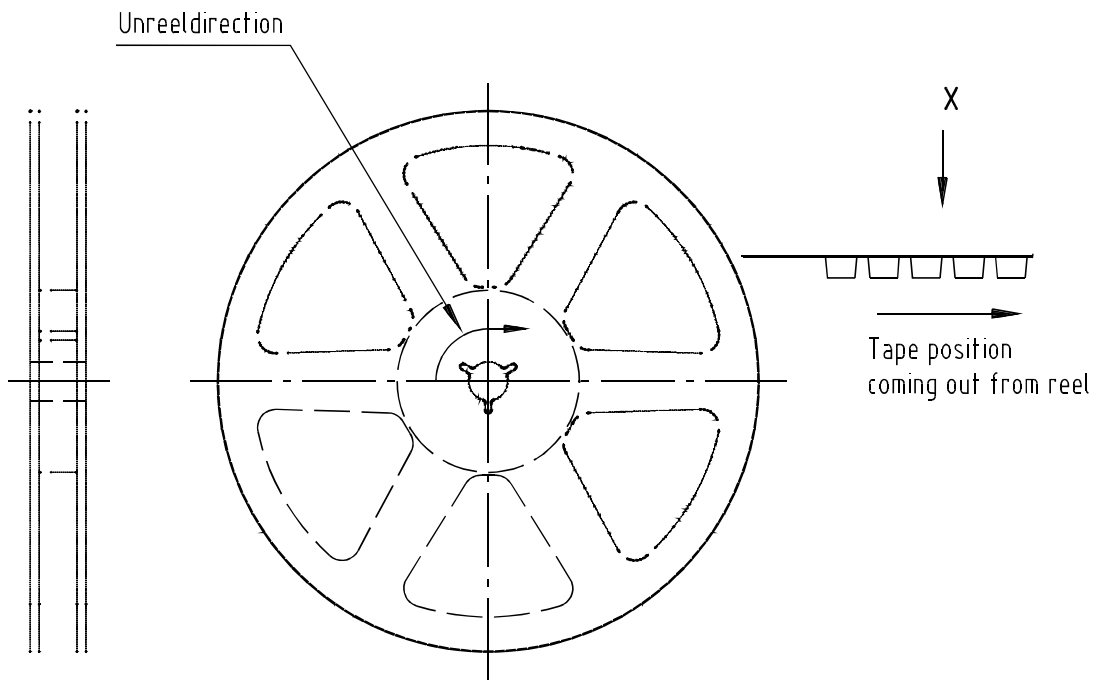
Extended Type Number	Package	Remarks
ATR0610-PQQ	PLL6	Area 1.6 mm × 2.0 mm, 0.5 mm pitch

### Package Information

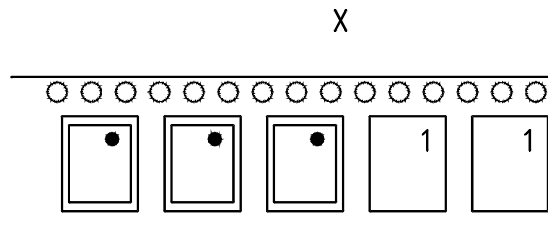
Package: PLL6, 1.6x2.0mm  
Dimensions in mm



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



technical drawings according to DIN specifications



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



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