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 × 2.0 mm)**
- **Few External Components**

Electrostatic sensitive device.
Observe precautions for handling.

2.7-V GPS Low-noise Amplifier

ATR0610

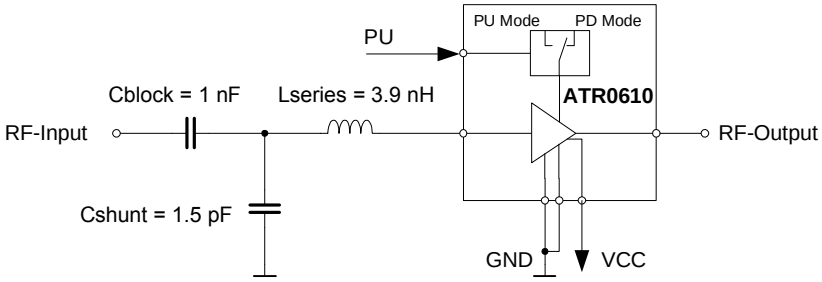
Preliminary

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 × 2.0 mm footprint to allow use in compact GPS receiver design.

Figure 1. Block Diagram



Rev. 4573C–GPS–02/03

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°C, Z_{load} = 50 Ω (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		Icp1		-9		dBm	A
9	Input 3rd-order intercept point	f1 = 1750 MHz f2 = 1925 MHz		IIP3		-1		dBm	C
10	Input 3rd-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 V, V_{PU} = 1.8 V, f = 1575 MHz, T_{amb} = 25°C, Z_{load} = 50 Ω (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

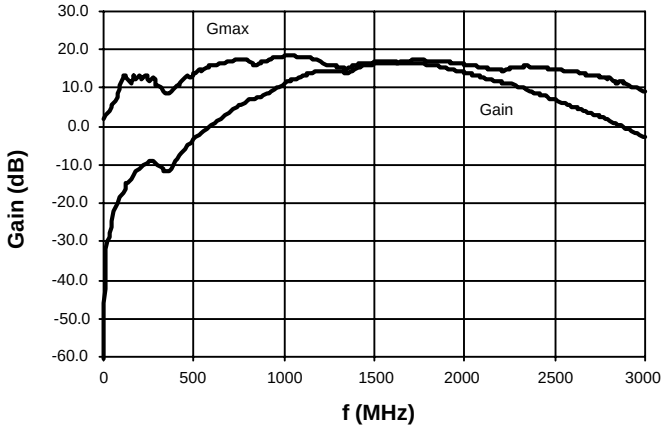


Figure 3. Input and Output Return Loss

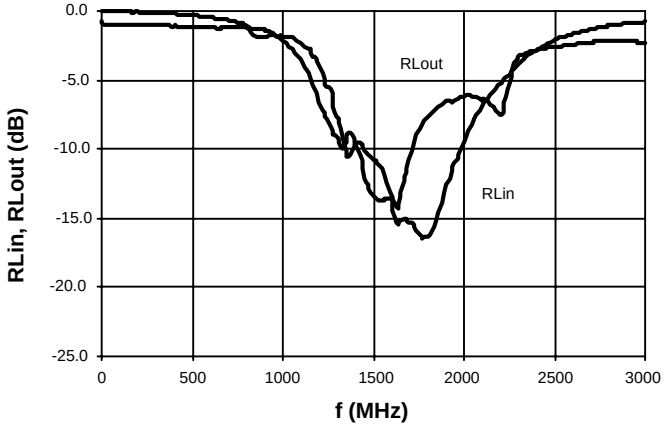


Figure 4. Reverse Transfer Function

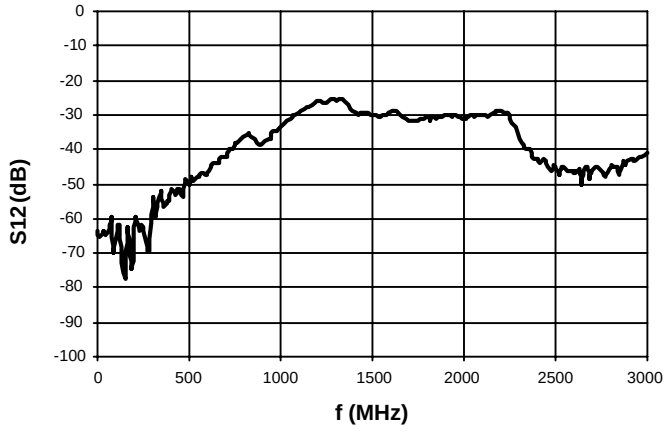


Figure 5. K Factor (=> Unconditional Stability)

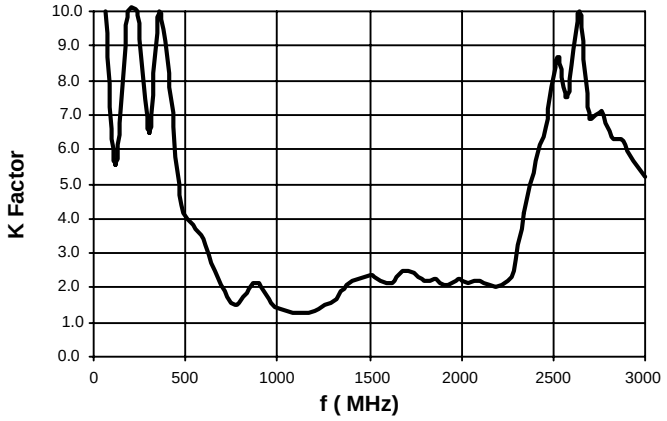


Table 1. Measured Scattering Parameters of Matched Device
(Given as Linear Magnitude and Phase in Degree)

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

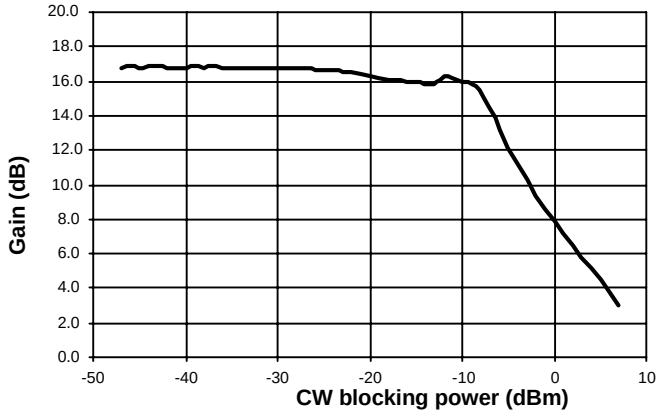


Figure 7. Out of Band Intermodulation Product 3rd Order (IP3)

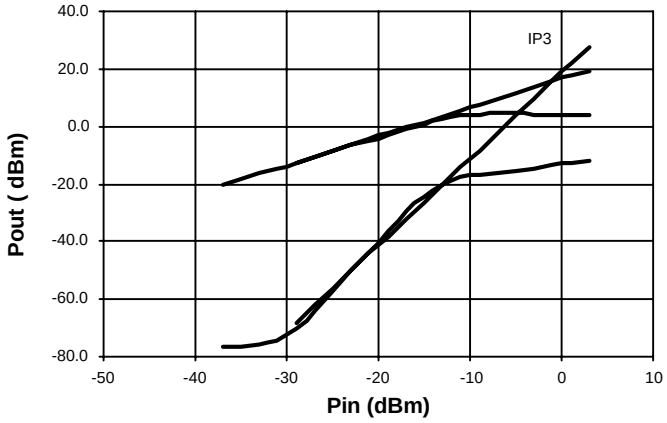


Figure 8. Inband Intermodulation Product 3rd Order (Inband IP3)

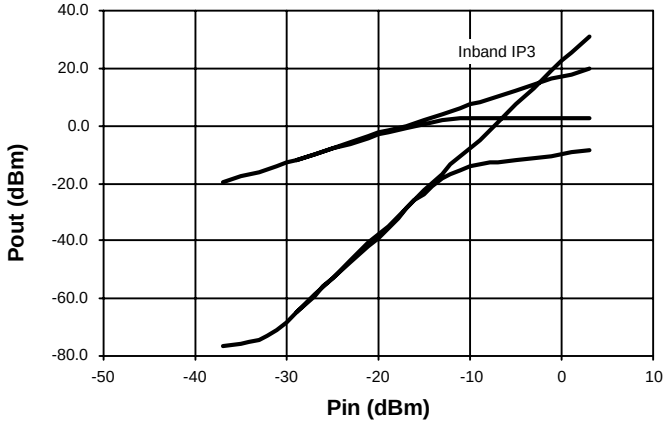


Figure 9. Noise Figure without any De-embedding

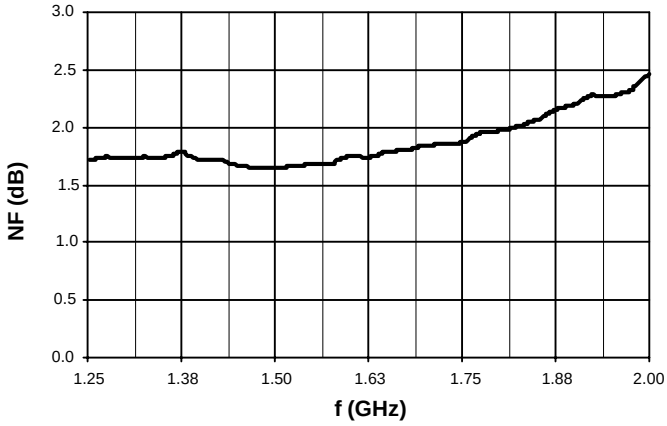
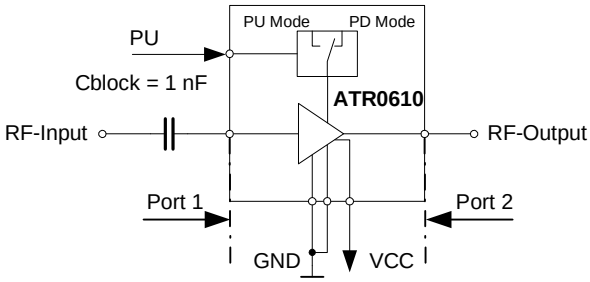


Figure 10. Reference Planes of Unmatched Device



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)

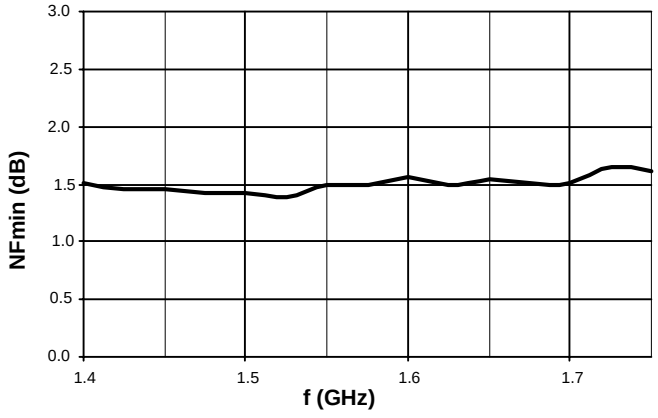
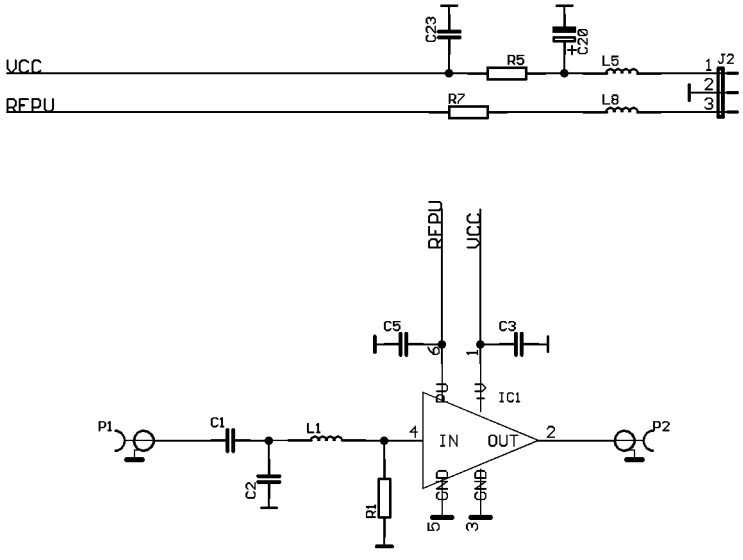


Table 3. Raw Noise Data of Unmatched Device (de-embedded)

f/GHz	NFmin/dB	|Γopt|	ϕ(Γopt)	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

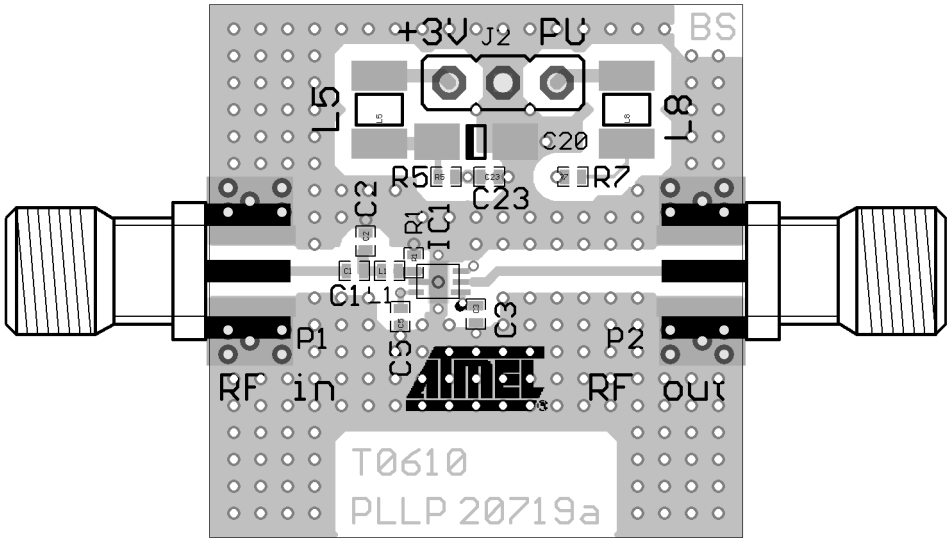


Bill of Materials of Demo Board

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.

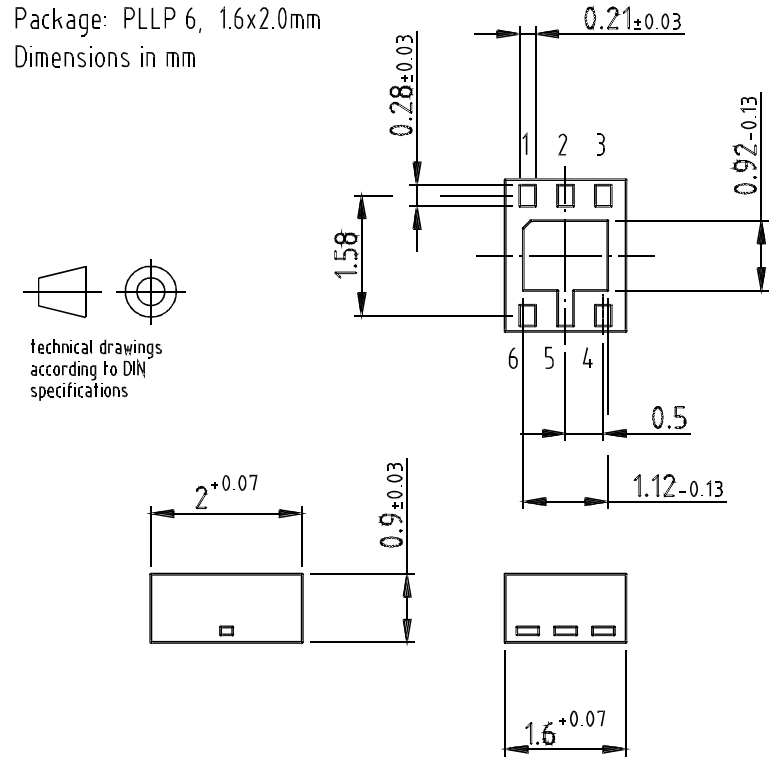
Figure 13. Layout of Demo Board



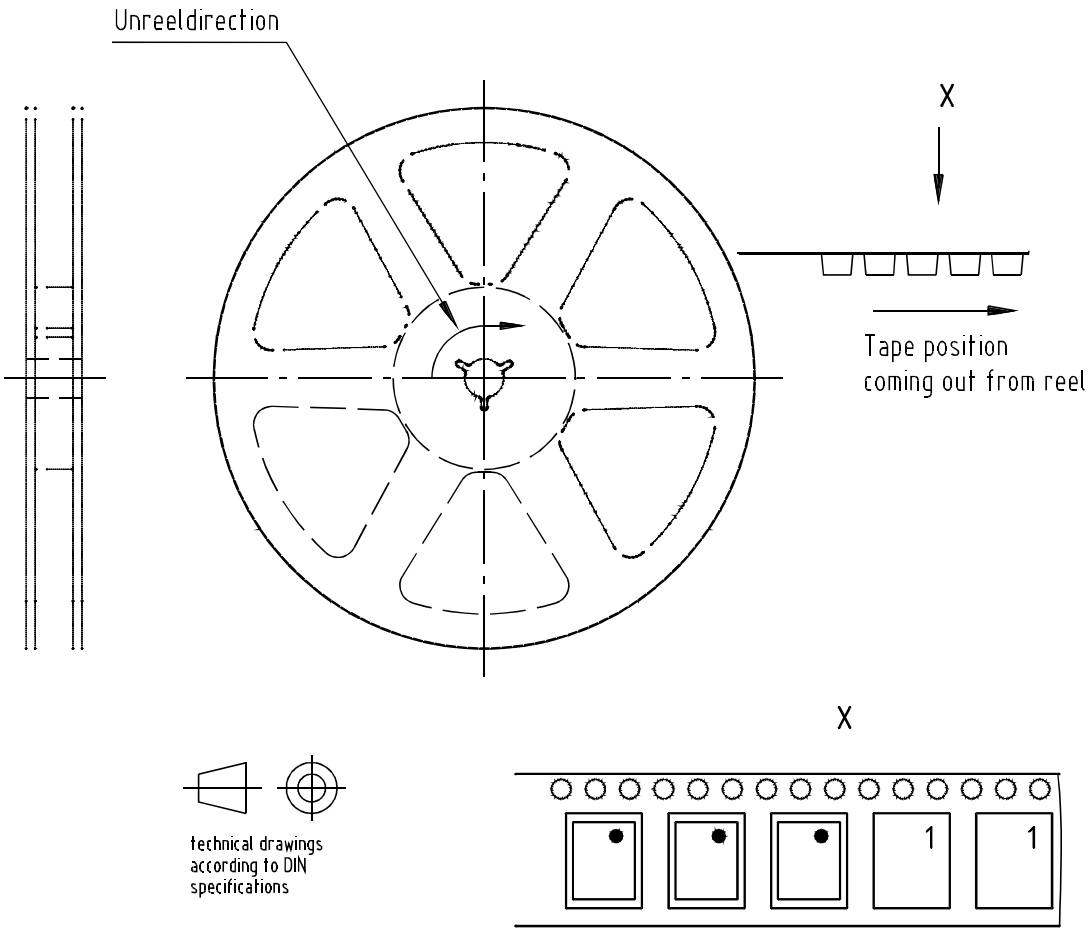
Ordering Information

Extended Type Number	Package	Remarks
ATR0610-PQQ	PLLP6	Area 1.6 mm × 2.0 mm, 0.5 mm pitch

Package Information



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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