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Swiss Space Summer Camp 2016

Low Noise Amplifier

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FH Zentralschweiz

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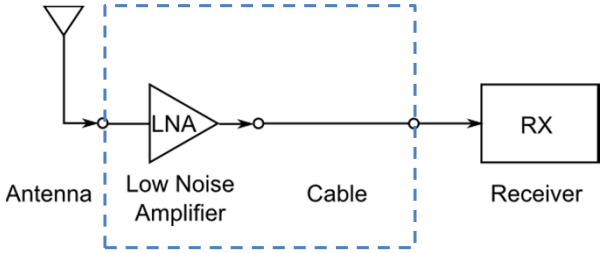
System block diagram

Simple ground station

- Only receiver path will be implemented
- Four main functional blocks
- Main objectives:
  - Receive signals from LEO satellites and ISS with reasonable quality
  - Simple to build and operate (no special technical skill needed)



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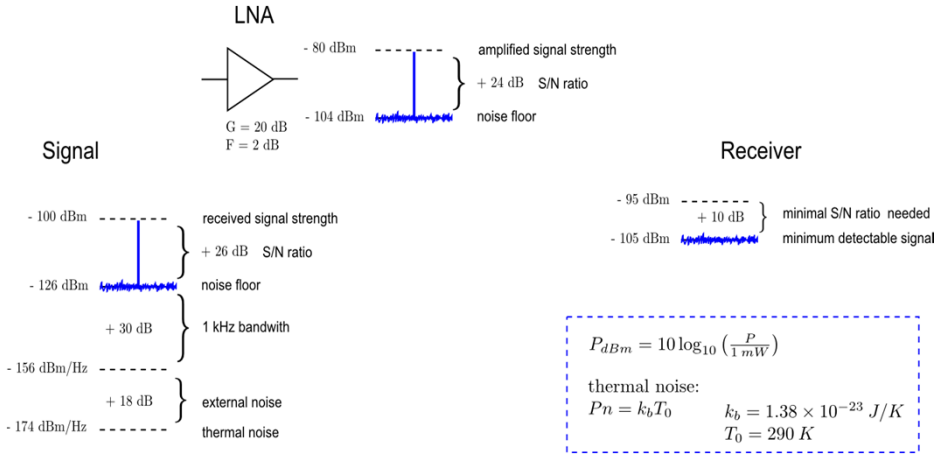
Why is there a LNA?



$$P_{dBm} = 10\log_{10}\left(\frac{P}{1\,mW}\right)$$

thermal noise:
$Pn = k_b T_0$ $\quad k_b = 1.38 \times 10^{-23}\ J/K$, $T_0 = 290\ K$

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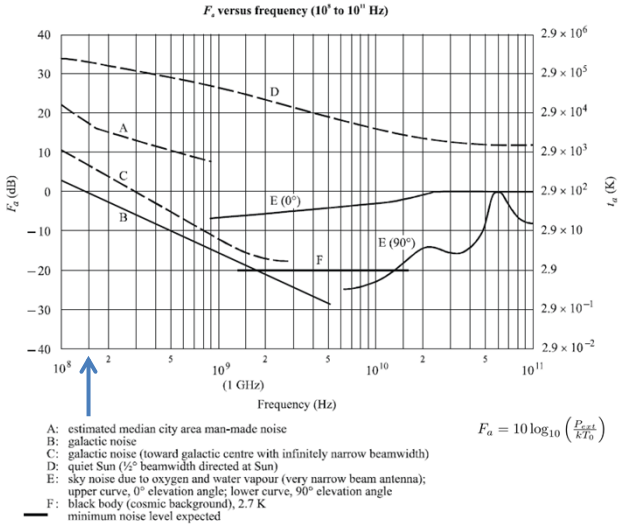
External Noise



A: estimated median city area man-made noise
B: galactic noise
C: galactic noise (toward galactic centre with infinitely narrow beamwidth)
D: quiet Sun (½° beamwidth directed at Sun)
E: sky noise due to oxygen and water vapour (very narrow beam antenna); upper curve, 0° elevation angle; lower curve, 90° elevation angle
F: black body (cosmic background), 2.7 K
minimum noise level expected

$$F_a = 10\log_{10}\left(\frac{P_{set}}{kT_0}\right)$$

Source:
ITU-R Rec. P372-9 [1]

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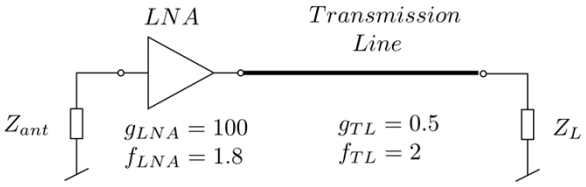
Does the placement play a role?

…yes, said Mr. Friis!

noise figure: $f = \frac{(P_s/P_n)_{in}}{(P_s/P_n)_{out}}$

Friis formula: $f = f_1 + \frac{f_2-1}{g_1} + \frac{f_3-1}{g_1 g_2} + \ldots + \frac{f_n-1}{g_1 g_2 \cdots g_{n-1}}$



$$LNA \rightarrow TL: \; f = f_{LNA} + \frac{f_{TL}-1}{g_{LNA}} = 1.8 + \frac{2-1}{100} = 1.81$$

$$TL \rightarrow LNA: \; f = f_{TL} + \frac{f_{LNA}-1}{g_{TL}} = 2 + \frac{1.8-1}{0.5} = 3.6$$

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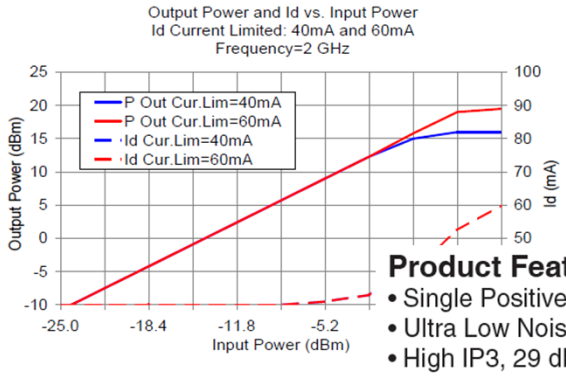
Low Noise Amplifier (LNA)



PSA-5451+

CASE STYLE: CA1389

Product Features

- Single Positive Supply Voltage, +3V, Id=30mA
- Ultra Low Noise Figure, 0.7 dB typ. at 0.5GHz
- High IP3, 29 dBm typ. 1GHz
- Gain, 18.8 dB typ. at 1GHz
- Output Power, up to +16.7 dBm typ.
- Micro-miniature size SOT-363 package

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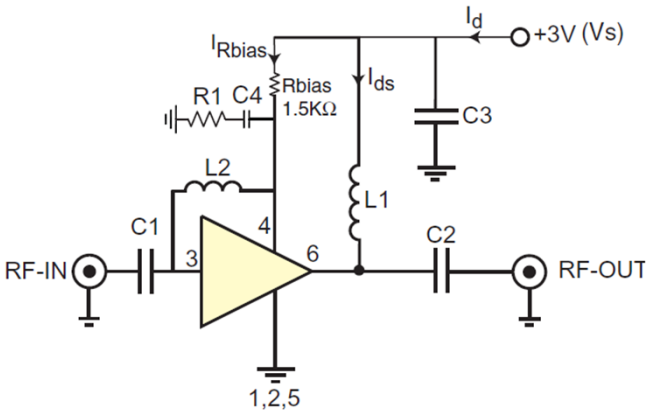
Electric schema



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Assembly and Test Instructions

- The following slides describe the various steps for assembling and testing the low noise amplifier and two coaxial cables.

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Item list for the LNA

- LNA board with pre-soldered SMD components
- 1 connection jack, red
- 1 Connection jack, black
- 2 sma right angle pcb socket
- 1 battery holder
- 1 lab cable, red, 2mm plugs
- 1 lab cable, black, 2mm plugs
- 5cm heatshrink tubing
- 2 Cable ties

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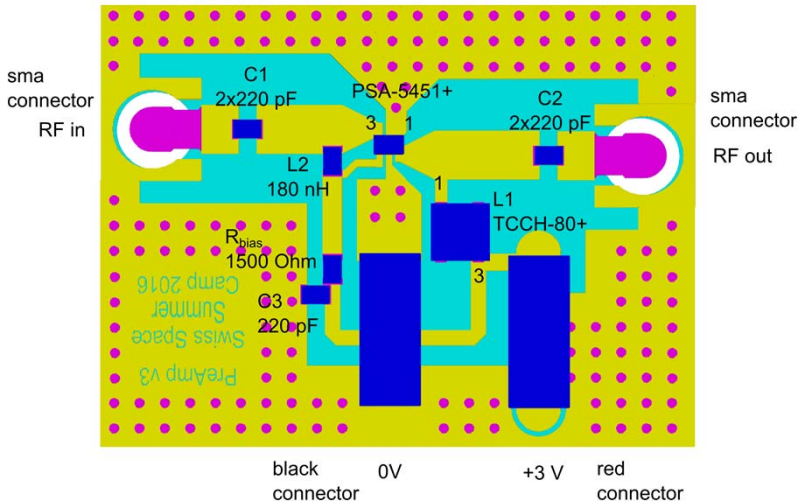
Parts placement drawing, top



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Soldering

- Solder the missing components according to the parts placement drawing.
- Trim the two pins of the battery holder down to 10mm.
- Cut off one plug each of the two lab cables (directly behind the plug) and remove 6mm insulation.
- Slip a 2cm length of heat shrink tubing onto the lab cables each.
- Solder the red lab cable to the battery holder pin signed with “+”.
- Solder the black lab cable to the battery holder pin signed with “-”.
- Slip the heatshrink tubing over the soldered connection and shrink it using a heat gun.

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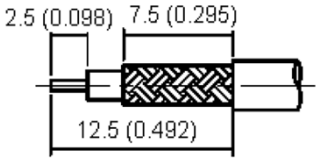
Preparing the coaxial cable

- Cut 5m length of RG-58 cable and carefully remove on both ends of the RG-58 cable the jacket and part of the braid and insulation according to the figure.
- Slip a 3cm length of heatshrink tubing onto both ends of coax cable.
- Assemble the SMA male connectors using the crimp tool.
- Finally shrink the tubing using a heat gun.



Stripping Dimension

Dimensions : Millimetres (Inches)

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Measuring the performance (1/3)

- For initial test measurements we use a lab power supply and a digital multimeter (DMM) for doing resistance and current checks.
- Perform the resistance checks to red female jack socket (+3) listed below (no power supply or battery connected):
  - Black female jack socket. Target value > 15 kOhm

    ……
  - L1, pin 1. Target value < 0.2 Ohm

    ……..
  - PSA -5451+, pin 3. Target value 1.5 kOhm

    ……..

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Measuring the performance (2/3)

- Connect a 3V power supply through an ampère meter to the LNA board and turn it on.
- Measure the current
  - Bias Current. Target value 30…40mA

    ……..
- If all measurements are on target, switch off the power supply and disconnect it and the amp meter.
- Insert two AAA size batteries into the holder and connect only the black cable. As soon you connect the red cable too, the LNA is switched on!

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Measuring the performance (3/3)

- Measure by means of a vector network analyser (vna) the scattering parameter S_{11} and S_{21} from the LNA.
- The scattering parameter S_{11} describes the input reflexion coefficient:

$$S_{11} = 10\ log_{10}(|\Gamma|^2)$$

- While S_{21} is a sort of gain since it relates an output wave to an input wave. Its magnitude squared is a power gain.
- Measure the S_{11} and S_{21} from the coax cable.
- Store the measurements as png-files for later documentation purposes.

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References

[1] *Radio noise*, ITU-R P.372-9, 2007.