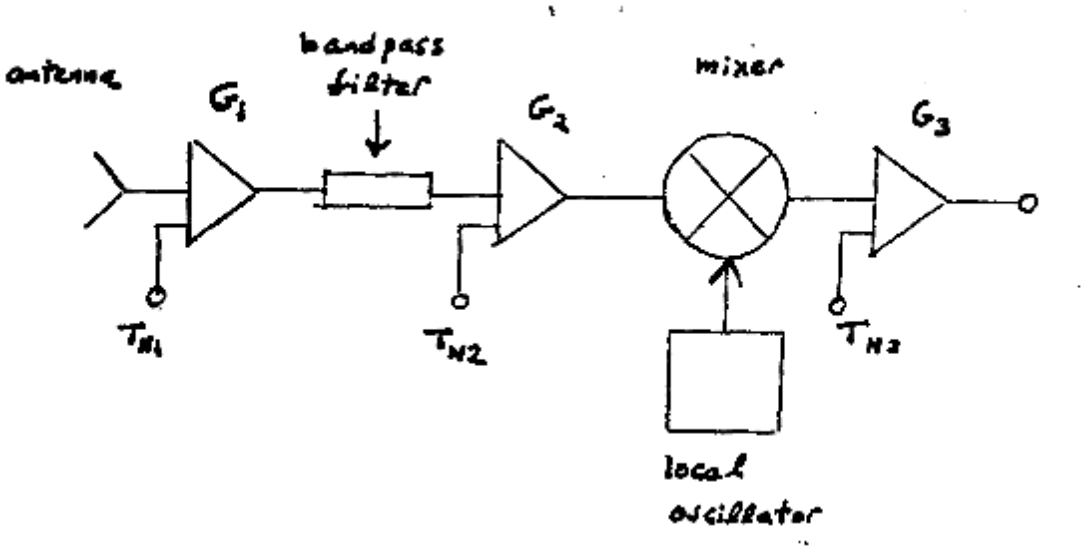
Astronomy 423 Homework Set 3

Due: Monday, Feb. 13

1. (a) Calculate the SEFD in Jy for a 100 m antenna assuming an aperature efficiency of 60% and a system temperature of 30 K. (b) If we pointed at a 1 mJy source for 100 seconds with 100 MHz bandwidth, what would be the rms noise in Jy? (c) If we pointed instead at a 100 Jy source for 100 seconds with 100 MHz bandwidth would the noise be less, the same, or more?

2. Given a blackbody spectrum, give a relation in the Rayleigh-Jeans part of the spectrum for the photon flux (number of photons emitted per cm^2 per second per Hertz) as a function of frequency.

3. Below is a block diagram of a simple radio receiver.



The antenna temperature is 10K. The characteristics of the receiver are as follows:

G1 = 25 dB, T_n1 = 50 K
G2 = 25 dB, T_n2 = 250 K
G3 = 80 dB, T_n3 = 250 K

Bandpass filter frequency range 4990-5000 MHz
LO frequency 4950 MHz.
Assume (incorrectly!) that the mixer and bandpass are lossless components.

(a) What is the receiver temperature? (b) What are the contribution of the second, and third stage amplifiers to the net receiver noise temperature?
(c) Draw the spectrum (accurately) of the signal that would be measured at the output of amplifier 3. This drawing should have properly labeled axes and the right numerical values should be provided (power in W/Hz vs frequency in MHz).

4. Write down a general expression for the sum of two waves of frequency ω, with different amplitudes and phases. Show that if their amplitudes have the same value A, the amplitude of the sum has the values 2A and 0 when the difference of phase has values 0 and pi, respectively.

5. Suppose one has a cable with an optical depth of 0.05, and it is operating at the ambient temperature of 300K. (a) if the input to the cable is a signal strength of 5 K, what is the temperature (in K) at the output? (b) would it reduce the system temperature to cool the cable?

6. More about astronomical literature and other nifty tools. Go to astro-ph
http://xxx.lanl.gov/archive/astro-ph
(by the time papers get to ADS they are old news) and search for a recent paper on the Perseus cluster by Gendron-Marsolais et al. (astro-ph/1701.03791). Figure 3 (left panel) shows a radio image (contours) overlaid on a greyscale image of the X-ray emission. (a). Find out the following information: Title, Authors, Journal, Publication date, general topic or type of source, radio telescope used, wavelengths used, general point the paper is trying to address (very general – should be in the abstract). This time, also try to discover the frequency of the observations in Fig. 3, the VLA configuration used, the bandwidth, the total time on source, and the rms noise in the image.

(b) Use the VLA exposure calculator at:
https://obs.vla.nrao.edu/ect/

to estimate the theoretical noise. What is the theoretical rms brightness temperature for these observations? What is the ratio of observed/theoretical noise?

(c) Extra credit (5pts):
Why is the answer in (b) greater than 1?