Overview of the layout and operation of a 2.3 GHz radio astronomy receiver

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Abstract

This paper studies the components that comprise a radio astronomy receiver.

1 Introduction

In order to have a well grounded understanding of radio astronomy, it is important to have a thorough understanding of the various components that comprise a radio astronomy receiver, and their respective characteristics.

2 Theory

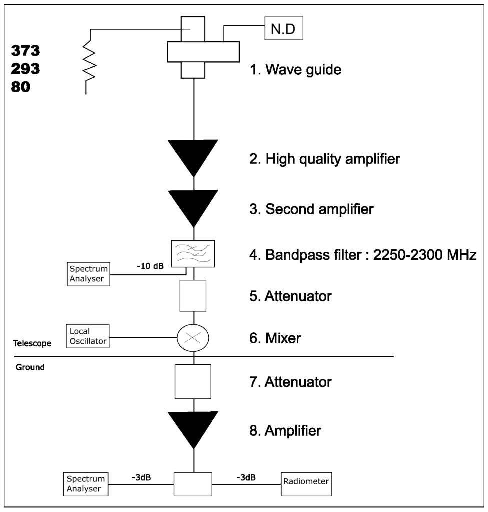

Figure 1: Radio astronomy receiver

Figure 1 shows the physical layout of a radio astronomy receiver.

Feed horns in the satellite dish channel the high frequency signals into waveguides. These wave guides propergate the signal towards the receiver and are shown at point 1 in the figure. Wave guides are used in order to minimise signal loss, and the use of coaxial cable is avoided as it is incredibly lossy at the receiving frequencies.

The amplifier at point 2 is a high quality amplifier. The noise temperature it introduces should be as low as possible. Any noise introduced at this point is amplified by this amplifier and every successive amplifier, so minimising the noise is of paramount importance.

The amplifier at point 3 in the figure is primarily a large gain amplifier, and less emphasis is placed on the noise it introduces than with the previous amplifier.

At point 4 in the receiver is a band pass filter. This filter basically comprises of four resonant wave guide chambers. The bandwidth of the transmitted signal is attributed to the filter at manufacture, although the frequencies which the filter transmits can be determined by physically adjusting the size of the chambers in the waveguides, with the use of a screwdriver.

A spectrum analyser is attached at this point in order to view the output of the filter. Feedback from the mixer further on in the circuit is visible on the spectrum analyser (see figure 2) as a large peak and gives us visual cues as to the position of the transmitted bandwidth within the spectrum.

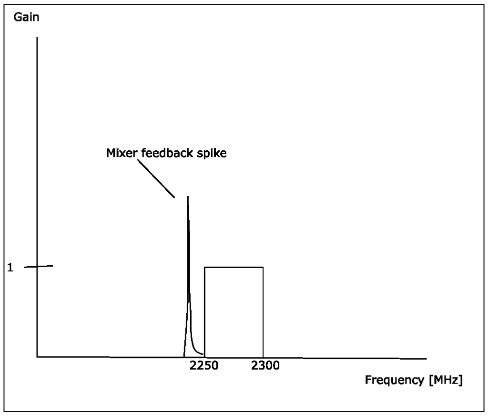

Figure 2: Spectrum analyser trace showing output following point 4

An attenuator is present at point 5. This prevents the mixer from being saturated, and any feedback from the mixer acts through the attenuator, thereby reducing its presence.

At point 6 the signal is mixed with a signal generated by a local oscillator, and effectively down mixed by the frequency of the local oscillator. Since the local oscillator is functioning at 2235 MHz, the signal is mixed down to frequencies between 15 and 65 MHz. The resulting signal can then be transported on coaxial cable with acceptable loss.

At point 7 the signal is attenuated in order to prevent saturating the following amplifier. This attenuation may occur occur along the length of cable running from the receiver down to the control room.

At point 8 the signal is passed through a large amplifier. Since this is the last stage of amplification the gain is of a great deal more importance then the noise introduced by the amplifier.

The resulting signal is then evenly divided between a spectrum analyser (see figure 3 and a radiometer.

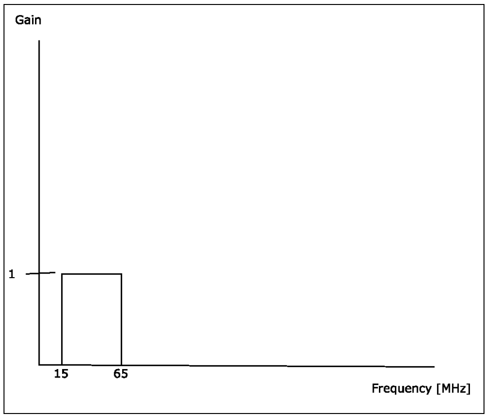

Figure 3: Spectrum analyser trace showing system output

3 Conclusion

Since the signal we are seeking to measure is faint in the context of the surrounding noise, it is vital that we know the purpose and characteristics of each component in the radio receiver.