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# Receiver for Jupiter



## Receiver Considerations for Jupiter

In this topic, the requirements of the receiver for Jupiter observations are discussed. So receiver characteristics required for Jupiter are defined in terms of operating frequency, Sensitivity, Gain, Bandwidth, Dynamic range etc.

**a. Frequencies for Observations: -**

The peak of Jupiter signals occur around 10MHz. Still this frequency is not that suitable, as it is very near to Ionospheric cutoff. The best suitable frequencies are in between 18 to 22MHz, as the chances of getting emissions are more. In practice 18.7MHz, 20.1MHz, 22.3MHz are common. The frequencies above 30MHz are not suitable because of less strength. The frequency of 20.1MHz is used for this project, as the probability of getting emission is high. So the entire receiver is designed considering 20.1MHz as the operating frequency.

**b. Sensitivity: -**

Whenever we receive any signal we receive it against the noise. Noise consists of the noise generated inside the receiver as well as the noise coming from the antenna. In the present case we have to consider two things while deciding the system temperature, first is receiver noise itself and second is the Cosmic noise or Galactic Background. Galactic background generates a steady hissing sound in the receiver. And Jupiter will always be received against the Galactic Background as the contribution of galactic background ( ~50000K) is much higher as compared to receiver noise at 20MHz. And it will be even more at lower frequencies. So major contributor for system temperature will be antenna temperature itself!
Still the sensitivity of the receiver required can be calculated as follows: -
Assuming the signal strength of Jupiter around 10^5 Jy, the power at antenna terminals can be calculated as
**Power at antenna terminals = Flux density X Aperture area X receiver bandwidth**

**The antenna with 8dB gain has aperture area of 111.7m^2 at 20.1MHz. The Dual Dipole Array has the gain of around 8dB in both the broadside case and endfire case.**

P= 10^5 Jy X 110meter^2 X 3.3KHz

P= 3.63 X 10^-16 Watts
Here the receiver bandwidth is assumed to be 3.3 KHz.

Thus converting power into dBm, we get the receiver sensitivity as -124.4dBm.

**Sensitivity = -125dBm.**

**c. Gain: -**

Since we are going to down covert the Jupiter signal at 20MHz to audio frequencies, the signal should be amplified to such a level so that it can drive a headphone i.e. to have audible signal.
So we have to amplify the signal to a level of 0.1Vrms. Assume that we have galactic background of 50000Kelvin. If the Jupiter signal is above the galactic background then only we can receive it. We have to amplify the background noise to a level of audible signal. i.e. We have to amplify the 50000Kelvin noise at receiver i/p to 0.1Vrms at o/p.
So Voltage at antenna terminals can be calculated as

P = k x T x B where k is Boltzman constant.

P= k x 50000 x 3.3KHz

P= 2.28 x 10^-15 Watts.

But Power = V^2/R
Thus for 50 ohm impedance,
V^2= P X R
V= square root (P x R)
V= square root (2.28 x10-15 x50)
V= 0.3375 microVrms

Now Voltage Gain is given by

AV = 20 log10 (Vout/ Vin)
AV = 20 log10 (0.1 / 0.3375micro)
AV = 109.43dB i.e. **AV=110dB**

**d. Bandwidth: -**

Usually the signals are band limited to 3-5 KHz. The bandwidth of the receiver is determined by the bandwidth of the low pass filter after mixer. Typically it is selected as 3.3KHz same as that of voice signals. In case of Guru Receiver which is direct conversion type the image frequency is also in the passband of the low pass filter thus giving the effective bandwidth of 6.6KHz.

i.e. if the signal frequency is 20.099MHz and LO is at 20.1MHz the intermediate frequency will be 1KHz. But at the same time, signal frequency of 20.101MHz will also give the same intermediate frequency and it will lie in the passband of low pass filter.

**e. Dynamic Range: -**

The thermal noise and other noise in the receiver sets the lower limit of the power span over which the receiver can operate. Noise in the receiver helps us to calculate Minimum Detectable Signal, which is defined as follows:
MDSin = kTB + 3dB + NF

Where
T= Receiver noise temperature
NF= Noise figure
K= Boltzman's constant

At the other extreme, when the i/p signal is too large the signal detection is limited by the distortion. Since active networks are nonlinear the intermodulation distortion occurs in the amplifiers, mixer etc. Because of the intermodulation distortion the compression in gain occurs, mainly because of the 3rd order intermodulation products.

For this two things are defined 1. Compression point and 2. 3rd order intercept point.

1. 1-dB compression point (P-1dB): - The point at which a networks power gain is down 1 dB from the ideal linear characteristics for a single tone is a figure of merit known as 1-dB compression point.

2. Intermodulation intercept Point: - It is the point of the intersection of network's linear and intermodulation responses. This is the point at which their powers would be equal if compression did not occur. Usually 3rd order intercept point is considered, as the 3rd order products reduces the network gain. The higher the third order intercept point of the receiver, the less susceptible is will be to spurious responses caused by strong multiple in-band signals.

With the help of the compression point and intercept point , the dynamic range of the receiver can be defined. The compression point dynamic range is the simply difference between compression point (in dBm) and receiver MDS (in dBm).

Compression Dynamic Range= P-1dB – MDS dB

Another way to define the dynamic range is the spurious free dynamic range, which is defined as follows: -

SFDR= (n-1)*(IPn(in) – MDSin)/(n)
Where
n= order of the intermodulation distortion
IPn(in)= Intermodultion intercept point wrt i/p power
MDS(in)= Minimum Detectable signal.

Which dynamic range to use is depends upon the application, as far as Jupiter's emissions are concerned the strength can go as high as 1 Million Kelvin. Assuming the receiver temperature of 1000 Kelvin, the rise in the signal strength is
10 log {(1 Million+1000)/1000} = 30dB

So for Jupiter receiver should at least have the compression point dynamic range of 30 dB.

**DR compression pt. >30 dB**

**f. NO need of AGC: -**
For radio astronomy receivers since we are interested in the signal amplitude variation, there is no need of AGC stage in the receiver.

**g. Concept of Direct Conversion Receiver: -**
In this type of the receiver the LO of the Mixer is made equal to the signal frequency itself. The local oscillator (LO) and mixer perform the important task of converting the desired radio frequency signals down to the range of audio frequencies. The local oscillator generates a sinusoidal voltage

waveform at a frequency in the vicinity of 20.1 MHz. Both the amplified RF signal from the antenna and the LO frequency are fed into the mixer. The mixer develops a new signal which is the arithmetic difference between the LO and the incoming signal frequency. Suppose the desired signal is at 20.101 MHz and the LO is tuned to 20.100 MHz. The difference frequency is therefore 20.101-20.100 = .001 MHz, Which is the audio frequency of 1 kilohertz. If a signal were at 20.110 MHz, It would be converted to an audio frequency of 10kHz. Since the RF signal is converted directly to audio, the radio is known as a Direct Conversion Receiver.

**Block Diagram of Receiver**

**Block Diagram with Specifications**

**Receiver Photos**

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