

0.5	35	1.5	120	2.5	226	3.5	359
0.6	43	1.6	129	2.6	238	3.6	374
0.7	51	1.7	139	2.7	250	3.7	390
0.8	59	1.8	149	2.8	263	3.8	406
0.9	67	1.9	159	2.9	275	3.9	422
1.0	75	2.0	170	3.0	289	4.0	438

Table to convert Noise Figure (NF) in dB to Noise Temperature in deg. K

The noise performance depends on the type of amplifying device used for the LNA stages. While C Band LNBS use bipolar transistors, KU band LNBS use GaAsFET transistors for the initial amplification. While it is customary to list the noise temperature for C Band LNBS, KU Band LNBS usually specify their noise, not as a Noise Temperature, but as a Noise Figure, in dB. The dB specification helps compute the total system noise, easily, but the more widespread use of a Noise Figure in db, particularly for Ku Band LNBS probably helps in "specmanship" for marketing purposes. KU band LNBS have much higher noise temperatures, which would not look good on paper. Hence they are quoted in units that look deceptively low, viz dB.

C AND KU BANDS

The atmosphere provides a low loss signal path for certain microwave frequencies. Satellite broadcasters therefore use this fact and provide satellite broadcasts at these frequencies. The earliest broadcast were at relatively low microwave frequencies. Infact, India's first rural education satellite broadcast from the SITE satellite in 1975 were at UHF frequencies.

India's first INSAT satellites offered Doordarshan TV broadcasts in the S Band at 2575 MHz & 2615 MHz. Even the INSAT 3C satellite launched on 24th Jan 2002 has 2 S-Band transponders. Most subsequent broadcasts have been in the C Band and Extended C Band range of frequencies. Infact India is the only country that has currently been licensed extended C Band frequencies for commercial use.

The amount of signal that a dish receives is directly linked to the frequency. For the same size of dish, the signals received will be larger for higher frequencies that lower frequencies. Technically, this implies that the same dish has a larger "Gain" at higher frequencies. Similarly, a smaller dish could be used at higher frequencies and yet provide the same signal gain. Recognising this, international broadcasters now utilise Ku and even Ka band frequencies for commercial television broadcast via satellite.

UPLINKING AND DOWNLINKING

A satellite receives television broadcast from a ground station. This is termed as "Uplinking" because the signals are sent up from the ground to the satellite. These signals are then broadcast down over the footprint area in a process called "Downlinking". Uplinking and Downlinking are shown graphically in Figure 1.

To ensure that the uplink and downlink signals do not interfere with each other, separate frequencies are used for uplinking and downlinking. Table 2 indicates the S, C and KU Bands for both uplinking and downlinking.

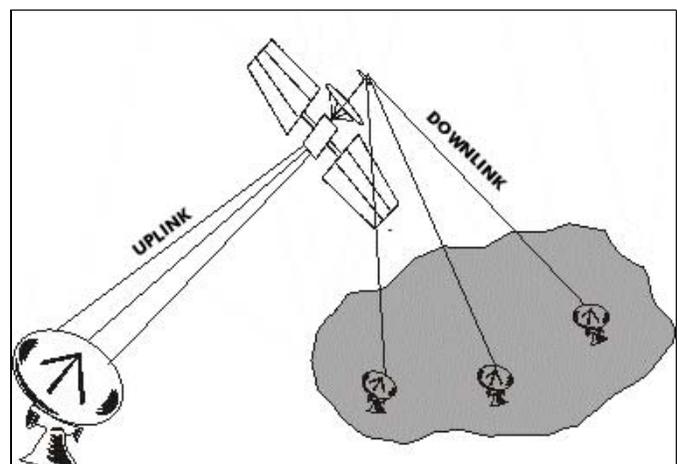


Table 2 : An Overview Of S, C, Ku & Ka Band Frequencies

	DOWNLINK FREQ (GHz)	UP-LINK FREQ (GHz)
S BAND	2.555 to 2.635	5.855 to 5.935
Extended C Band (Lower)	3.4 to 3.7	5.725 to 5.925
C Band	3.7 to 4.2	5.925 to 6.425
Extended C Band (Upper)	4.5 to 4.8	6.425 to 7.075
Ku Band	10.7 to 13.25	12.75 to 14.25
Ka Band	18.3 to 22.20	27.0 to 31.00

THE LNB

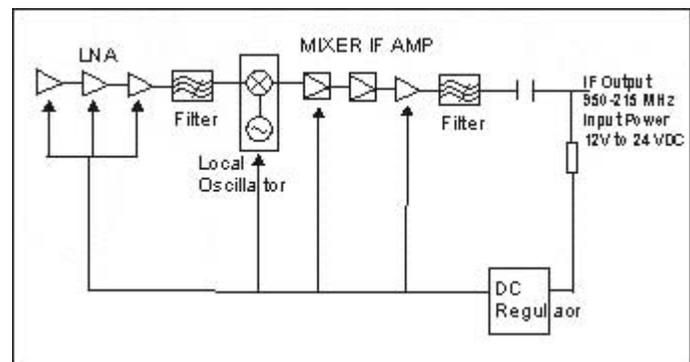
After the C or KU band frequencies are amplified by the LNA, they need to be processed. The processing is done in the satellite receiver which is usually located 10 meters to 50 meters away from the dish antenna. Microwave signals in the S, C or KU Band would suffer very high attenuation if they were carried via coaxial cable from the LNA to the Satellite Receiver 50 meters away.

To overcome this problem, the microwave signals are converted to a block of frequencies from 950 MHz to 2150 MHz. Hence, incoming signals received by the LNA at 2 GHz, 4 GHz and even 12 GHz are even block converted down to 950 MHz to 2150 MHz. This range of frequencies is referred to as Intermediate Frequencies since their range of temporary or intermediate frequencies in the chain of satellite reception which receives microwave signals and finally yields video and audio signals from the satellite receiver. This function is carried out by a "Block Converter" located within the LNB. A combination of Low Noise amplifier + Block converter is referred to as an LNB. A block diagram of a commercial LNB is shown in Figure 2.

The Block Converter consists of 4 important sections as shown in Figure 2.

MIXER

The Block Converter uses the Hetrodyne principle for conversion of a block of S, C or KU Band frequencies to the IF or Intermediate Frequencies. The Hetrodyne principle mixes an external fixed frequency with the incoming frequency. The output from the mixer is a series of signals at the sum and difference of the two inputs to the mixer. Outputs are also produced at multiples of these frequencies. A simple filter is used to suppress all frequency components except those required.



LOCAL OSCILLATOR

The Local Oscillator (LO) is a section of the LNB and gets its name since it is present locally or within the LNB. The local oscillator produces a fixed output at a pre-determined frequency. The Local Oscillator (LO) frequencies have been standardised by LNB manufacturers worldwide for S, C, Ku and even Ka band frequencies. The LO frequencies have been selected to yield an output in the IF (950 MHz to 2150 MHz) range, for all types of LNBs. As a result, universal satellite receivers can be designed for reception of C and KU Band signals through the same satellite receiver.

Table 3 - Local Oscillator Frequencies

Reception Freq.	L.O. Freq.	Output Freq.
2.5 to 2.7	3.65	950 to 1150
3.4 to 4.2	5.15	950 to 1750
4.5 to 4.8	5.95	950 to 1250
10.7 to 11.8	9.75	950 to 2050
10.95 to 11.70	10.0	950 to 1700
11.7 to 12.5	10.6 / 10.75	950 to 1750
12.25 to 12.75	10.6 / 10.75	950 to 1450
12.25 to 12.75	11.3	950 to 1450
12.5 to 12.75	11.475	1025 to 1275

Table 3 lists the Local Oscillator frequencies for various LNBS. Do note that since S and Extended C Band LNBS are not used universally, the local oscillator frequency indicated is typical but not an international standard.

The output frequency is directly related to the local oscillator frequency. Hence it is very important to have an extremely stable (fixed) local oscillator frequency. To ensure this, most LNBS utilise a crystal oscillator for the LO. This ensures that the LO frequency does not change either with the Input voltage to the LNB or due to temperature changes that the LNB is exposed to. Keep in mind that the LNB is mounted outdoors and is often subjected to sub-zero temperatures with high wind velocities or high ambient temperatures when directly exposed to sunlight in tropical climates such as India.

SAMPLE CALCULATION

To further illustrate the relevance of a Local Oscillator frequency, let us consider the case of typical C Band reception. The C Band LNB is designed to receive satellite broadcast from 3,800 MHz to 4,200 MHz. The LO within the LNB is standardised at 5150 MHz.

Hence when receiving a broadcast at 3,800 MHz, the output frequency of interest is
 $5150 - 3800 = 1350$ MHz

Similarly, when receiving a broadcast at 4,200 MHz, the output frequency of interest is
 $5150 - 4200 = 950$ MHz

We see that both these output signals viz. at 1350 MHz and 950 MHz lie in the standard IF frequency band that satellite receivers accept.

For extended C Band reception, the LO frequency is increased to 5950 MHz so that the output continues to fall within the IF range.

In the case of KU Band LNBS, the local oscillator frequency is actually less than the KU band signal. However the LO frequency is chosen so that the difference always lies in the IF frequency range for satellite receivers.

FILTER

As shown in the LNB Block diagram Figure 2, Bandpass Filters are introduced both before and after the mixer. The filters after the mixer suppress or filter out all frequencies except the required frequency which is the difference between the microwave broadcast and the local oscillator frequency.

THE KU BAND

The KU Band actually used for downlinking spans a wide range of frequencies viz. 10.7 GHz to 12.75 GHz. 1 GHz = 1,000 MHz. This wide range of KU Band frequencies cannot be handled by a single local oscillator frequency. Initial KU Band reception was at 10.7 GHz to 11.8 GHz. The LNBs then utilised a LO of 9.75 GHz.

Table 3 indicates various KU Band segments and local oscillator frequencies used to receive these signals.

IF AMPLIFIERS

The output of the mixer is an IF signal, at a fairly low level. Since this signal is of a specific bandwidth only, it can be easily amplified, significantly. An LNB often includes atleast 2 stages of IF amplification. This amplified signal is then filtered and fed to the output via a DC blocking capacitor. The capacitor allows the signal to pass through but steers the power coming from the satellite receiver, to the LNB power supply.

UNIVERSAL LNB

KU Band LNBs today effectively split the KU band into 2 frequency segments and utilise separate local oscillators for each of these frequency segments. As an example, the COLORADO Universal LNB receives satellite transmissions from 10.7 GHz to 12.75 GHz. For the lower frequency band, the local oscillator operates at 9.75 GHz. For the upper frequency band, the local oscillator operates at 10.6 GHz, or sometimes 10.75 GHz.

The necessary Local Oscillator is activated by send the LNB a burst of 22 KHz signals, from the satellite receiver. When the Satellite receiver is told by the user to tune into a Satellite Channel between 11.7 GHz to 12.75 GHz, the 10.6 GHz local oscillator is activated with a burst of 22 KHz signals.

The absence of the tone burst, activates the 9.75 GHz local oscillator.

Table 4 : Universal LNB Polarisation & Power Supply Voltages	
Power Supply Voltage	Received Polarisation
12.5 VDC to 14.5 V DC	Vertical Pol.
15 V DC to 24 V DC	Horizontal Pol.

POWER SUPPLY

The LNB is remotely powered from the satellite receiver. The same coaxial cable that carries the IF signal from the LNB to the receiver carries power from the receiver to the LNB.

As indicated in the LNB Block Diagram

(Figure 2), a DC regulator is built in. A DC regulator provides a fixed voltage to all sections of the LNB, irrespective of the input voltage.

The Universal LNB operates for DC voltages fed to it in the range of 12.5 Volts upto 24 Volts DC.

The current generation of Universal (Ku Band) LNBs are designed to switch their operating characteristics, based on the input Power Supply Voltage it receives, from the Digital Satellite receiver, through the IF Cable.

If the Power Supply voltage is between 12.5 V DC to less than 15 volts, the LNB will respond to

and receive only Vertically Polarised transmissions.

If the Power supply Voltage ranges from more than 15 volts to 24 V DC, the Universal LNB will respond to & receive only horizontally polarised transmissions.

The digital satellite receiver usually takes care of this automatically. When the receiver sends a command to tune in to a Vertically Polarised signal, it drops the power supply voltage to between 12.5 V DC to 15 V DC.

When the receiver needs to receive Horizontally Polarised signal, it raises the power supply voltage to between 15 V DC to 24 V DC.

OVERALL LNB GAIN

Most LNBs publish an impressive gain figure of approximately 65 dB. While several advertisements trumpet this figure, a 65 dB gain is fairly standard and is required of all LNBs to amplify the microwave signals to levels required by the satellite receiver. The buyer need not pay undue attention to this parameter. A far more important specification is the Noise temperature, which indicates how much Noise is added to the signal, by the LNB !

It is hoped that this article will provide readers a basic understanding of S, C & Ku band LNBs, including the relevance & importance of noise & the various IF & Local Oscillator frequencies. ■

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