SatCritics Technicals

Understanding lnb specifications

by The Professor (15 November 2002)

Want to know what lnb specifications mean. Well read on!

An lnb, or **low-noise block downconverter**, picks up the signals collected by your satellite antenna, amplifies them, and converts them to a lower frequency more suited to transmission via a co-axial cable to your receiver's input circuits. Without this frequency down conversion and amplification the signal would have to arrive at your receiver by means of microwave waveguides, a veritable plumber's nightmare of pipework, which would do little to improve your domestic décor and harmony.

The lnb should accomplish this without adding too many spurious signals of its own.

The following table shows the recommended specifications for lnbs, according to the Eutelsat web site, for users of the Hotbird satellite cluster. The full document is available as a pdf file here - http://www.eutelsat.com/fr/satellites/pdf/dealers/info_installer_hot_bird_dvbs.pdf

RF frequency range:	10.70 - 12.75 GHz
Lower band range	10.70 - 11.70 GHz
Lower band local oscillator frequency	9.75 GHz ± 5 MHz
Upper band range	11.70 - 12.75 GHz
Upper band local oscillator frequency	10.6 GHz ± 5 MHz
IF frequency range (minimum)	950 - 2150 MHz
Small signal gain over RF frequency range	40dB ≤ Gain ≤ 65dB
Max. amplitude variation over IF frequency range	2.0 dB (within any 36 MHz bandwidth) 1.5 dB (within any 27 MHz bandwidth) 8.0 dB (over entire IF range - DTH) 5.0 dB (over entire IF range - SMATV)
Max. group delay variation over IF band	20 ns (within any 36 MHz bandwidth)
Multi-carrier intermodulation ratio	≥ 35 dB.
Local oscillator intermodulation products at lnb output	< -60 dBc (in the frequency band 950 - 2150 MHz)
Local oscillator phase noise	
	-50 dBc (1 kHz)
	-75 dBc (10 kHz)
	-95 dBc (100 kHz)
Spurious components at LNB output	-60 dBc (in frequency band fc ± 120 kHz)
LNB isolation	> 26 dB
LNB input RF interface: (optional, if waveguide is employed):	PBR 120 (rectangular), or C120 (circular) with gasket groove
Antenna feed RF interface: (optional, if waveguide is employed):	UBR 120 (rectangular), or C120 (circular) without gasket groove
Output IF connector	IEC 169-24 type F, female
IF output characteristic impedance:	75 Ω
LNB output return loss (this is the recommended value in the ETSI BSS and FSS specifications)	≥ 8 dB (over the frequency range 950 - 2150 MHz)
Recommended switching control signals	DiSEqC™ 2.0 e
DC supply voltage (assuming conventional switching method)	+11.5 to +19 V
maximum current (assuming conventional switching method)	250 mA (single-band) 300 mA (dual-band)

But what does it all mean?

The frequency range stuff

This is all pretty self-evident. The lnb has to cover all of the frequencies that the satellite broadcasts on, so a coverage of 10.70 - 12.75 GHz. is essential if you are going to be able to see all the KU band programming. The local oscillator frequency is shown with a tolerance of 5MHz either way. This tolerance is fine for Hotbird, where all of the transponders are wideband ones. Searchers for SCPC narrow bandwidth channels might be better off with a tighter frequency tolerance.

The local oscillator frequencies of 9.75 and 10.6 GHz are now acknowledged standards for universal lnbs, and all digital satellite receivers with the DVB logo should support them. Some (usually the more expensive) receivers support other local oscillator frequencies, so strict adherence to these frequency values may not be absolutely essential.

The IF frequency range is the range of frequencies that your receiver should tune to if you are going to be able to see all the frequency ranges covered by a universal lnb.

The lnb amplifier details.

This bit describes how well the lnb actually works, and requires a bit of interpretation.

Gain

The lnb gain tells us how much the incoming signal is amplified before being sent off down the coaxial cable to the receiver. The range of gain specified is between 40dB and 65dB (somewhere between 10,000 and 4,000,000 times the incoming signal power). At first sight, the highest gain you can get would be the obvious thing to look for; but that is not the only criterion when it comes to lnbs.

When you have a big dish looking at a high power cluster of satellites like Hotbird or Astra1 the gain can be so high that the receiver is overloaded with signals. Yes, it is possible to get too much signal!

Even if the receiver itself can handle a massive diet of signal, there can be problems within the lnb itself when large amounts of amplification are employed. This leads to the generation of spurious signals and distortion products, in much the same way as turning up the volume on a transistor radio does. This distortion will interfere with the reception of your signals - there's more on this later further down the spec.

So unless you have specific reasons to want an ultra high gain lnb, (perhaps you are looking for a weak carrier and you can guarantee the absence of unwanted high power signals on the same satellite) then look for a gain around 50-60dB.

Gain Flatness

To let the demodulator in the receiver work effectively, the gain at all frequencies in the within any broadcast channel should be the same. This isn't a very difficult requirement to meet, except perhaps at the edges of the band, as long as the lnb is constructed properly. Notice that the DTH (direct to home) requirements for the flatness across the *entire band* are less severe than for the SMATV (satellite master antenna television- e.g. distribution around a block of flats), where we might expect additional splitters, switches and amplifiers in the signal path.

Group Delay Variation

Group delay refers to the time shift experienced by signals of differing frequencies. If high frequency signal components were delayed by significant amounts of time compared with low frequency signal components, then the demodulator in your receiver is going to have a hard time.

It's hard to think of a good analogy to this, *perhaps this one will do*.

Imagine a set of traffic lights at a road junction, but the speed of propagation of the light is dependent on the light's colour. Imagine that the speed of propagation of the green light is normal, but the red light is only propagated at a speed of one metre per second.

Sitting in your car at the lights you would see the green light go off, but the illumination from the red light would take a few seconds to reach you, so you would see no light at all for a few seconds.

After a while the red light would arrive and all seem to be well again.

But then, when the red light goes off and the red green light comes on, you would see both lights at once for a while - until all of the red light still on its way to you had passed you by.

Pedestrians and car drivers, trying to demodulate the on/off digital signals from the traffic lights, would quite often get it all wrong - there would certainly be a lot of accidents at the junction!

But reduce the difference in light's propagation speeds, or the *group delay*, and the number of accidents will reduce too.

I have never seen a lnb spec that even mentions group delay. If the gain flatness criterion is met, we can but hope that the group delay one will be met too.

Multi-carrier intermodulation ratio

Earlier I said that it was possible that a big dish looking at a high power cluster of satellites like Hotbird or Astra1 could cause the receiver to be overloaded with signals. One effect of this overload would be for the transponders to interfere with each other inside the lnb's amplifier, resulting in signals that weren't in the original broadcasts magically appearing at the lnb output as distortion products. This would be fine if there was no legitimate signals at the point where the interference pops up, because you could just ignore these 'ghost signals'. But this isn't going to happen on a cluster like Hotbird, as there is going to be a legitimate signal on *every* frequency in the KU band. If these spurious signals are too large then they are going to severely spoil your fun. The Eutelsat specification recommends that such signals should be at least 35dB down when compared with the wanted signals.

Once again, I have never seen a lnb specification that quotes this parameter. Some lnb specifications do mention such things as the 'third order intercept point' or the '1 dB gain compression point', which at least shows that the manufacturer has considered the problems of handling high power signals. If you see such details in the specification then high numbers are good to see, look for a third order intercept point of about 15 dBm, or a 1dB gain compression point of about 5 dBm.

If these values are not quoted, then this criterion has a better chance of being met in a lower gain lnb. Yet another reason not to look for a super high gain lnb.

Local Oscillator intermodulation products

There is another source of interfering signals built right into the lnb itself - the local oscillator. Using a properly balanced mixer, unwanted intermodulation products should be at least 60dB down. There is, of course a wanted intermodulation product too, that's the frequency-translated signal fed out to the coaxial output connector!

Local oscillator phase noise

Fact: digital satellite signals are phase modulated.

What a lnb should do is frequency shift the incoming signals down to the IF output frequency and amplify them without altering the vital phase modulation in the signal.

The worst thing your lnb could possibly do is to add further phase modulation to the signals. It doesn't matter how big your dish is, or how' quiet' your lnb is if you let the local oscillator in the lnb wantonly add its own phase modulation and 'scribble' over your precious signals.

The phase noise values suggested by Eutelsat here are the recommended phase noise levels for wideband MCPC (multi-channel per carrier) signals. If you are looking for SCPC (single channel per carrier) or other narrow bandwidth signals, then you will be better off looking for a specification that is better than that shown.

It is remarkable how few lnb manufacturers mention phase noise. Some, not very helpfully, say that it is low. Phase noise is one of the most important parameters by which we can judge a digital lnb.

By comparison, the Eutelsat spec makes no mention of the noise factor of the lnb, held to be so important by advertisers, dealers, magazines, and the man in the pub!

Hopefully a low-noise lnb will probably have a low phase noise too. But a low noise factor lnb, by itself, is no guarantee of good reception. Indeed, there comes a point where the further reduction of white noise within the lnb is pointless, because the noise picked up by the antenna and feedhorn will be many times more significant than the noise contribution of the lnb.

Its time for another analogy!

Imagine that you have slight hearing problems and have to wear a hearing aid, it's a good hearing aid but it makes a hissing noise in your ear. Despite this, it is good enough to understand people talking up to 20 metres away from you in a quiet room.

One day you go to a bar with friends, there are a lot of other people talking, laughing, and there is music playing too. You find it hard to understand your friends under these environmental conditions, so you buy a more expensive less hissy, hearing aid and can now understand people 100 metres away in the quiet room. *But in the bar you still can't understand your friend's conversations.*

This is hardly surprising, as the noise in the bar is much greater than the hiss made by the hearing aid.

You later notice that your friends are also having trouble hearing each other and occasionally resort to cupping their hand behind their ear to hear better. They are making their ears more effective by making their hearing more directional and sensitive.

The moral of this tale is that a bigger, more directional antenna is often a better solution than a quieter lnb!

Microwave noise figures are a notoriously difficult thing to measure, because there is no such thing as a noise figure meter to measure them with. All noise factor measurements are inferred from running an experiment, which attempts to distinguish between internally generated noise and noise naturally present in the testing environment and the measuring instruments. When people start worrying about fractions of a dB it is time to start querying how these measurements are made and how repeatable the test results are.

Spurious components at LNB output

Just in case we haven't covered all the possible sources of interfering signals, there's another catch-all category - simply labelled spurious components. Once again, the bigger the negative number the better things will be.

LNB isolation

This parameter applies to multiple lnb set-ups, including monoblock lnbs, and specifies the maximum amount of signal that should leak through from one lnb to the other. The value shown in the specification seems a very low target to aim for compared with some of the other specifications here. Serious hobbyists, looking for the ultimate in reception ability, will probably not be using such a set-up anyway.

The other stuff

This specifies the connectors, voltages currents and interfaces to the outside world - it also, not unsurprisingly, incorporates a further recommendation of the DiSeQc standards.

The only mysterious feature here is the lnb output return loss. This loss should be as high as possible, and is a measurement of by how much spurious signals coming *up* the lnb coaxial cable and re-entering the lnb are reduced before re-emerging from the socket. These signals can originate from the receiver and/or from signal reflections caused by discontinuities in the coaxial cable run. These rogue signals can cause no end of bother and can even be responsible for the mysterious inability to receive certain transponders from a satellite. A high return loss will help reduce the level of these unwanted signals.

And Finally

How do 'real world' lnbs stack up against the Eutelsat recommendations?

The following table shows the specification of the Cambridge AE57 lnb, a popular, attractively priced lnb.

	Manufacturer's Specified value.	Meets Eutelsat Requirement?
Model No.	AE 57	Not applicable
Size	115 X 55 mm	Not applicable
External Feed Dia.	40 mm	Not applicable
Weight	250g	Not applicable
Output Connector	SINGLE F-Type Female	Yes
Input Frequency 1	10.7 to 11.7 GHz	Yes
Input Frequency 2	11.7 to 12.75 GHz	Yes
Band selection RF1 to RF2	High band by 22KHz tone	Yes
Output Frequency 1	950 to 1950 MHz	Yes
Output Frequency 2	1100 to 2150 MHz	Yes
Input VSWR	2.5:1 typ	Not in spec, 1:1 is optimum, but this is OK
Output VSWR	2.0:1 typ	Not in spec, 1:1 is optimum
Conversion gain	48dB min dB min	Yes - a little low
Gain Flatness	+/- 0.5dB over 26 MHz segment	Yes
Noise figure	0.6dB dB	Not in Eutelsat spec.
Local Osc. RF1	9.75 GHz	Yes
Local Osc. RF2	10.6 GHz	Yes
Loc. Osc. Stability setting	+/-2 MHz	Yes - even when combined with below
Loc. Osc. Stability temp.	+/-2 MHz (-30 to 60°C)	Yes- even when combined with above
Phase Noise		
1Khz	-50dBc dBc	Yes (just)
10kHz	-75dBc dBc	Yes (just)
100kHz	-95dBc dBc	Yes (just)
Cross polar isolation	20 dB typ	Not in spec.
3rd Order Intercept	+15dBm typ	Meets the Prof.'s recommendation.
Current drawn	150mA max	Yes
Polarity	V/H	Yes
Supply voltage	11.5-14.0 v	Yes
Supply voltage	16.0-19.0 v	Yes
Digital LNB	Yes	N/A

Not surprisingly, all the items in the Cambridge specification appear to meet the Eutelsat requirements.

Hobbyists looking for more difficult signals might profit from more gain, higher frequency stability, and lower phase noise, but such things will cost them more money!

Lets see what MTI gives us in their AP8-TW lnb for just a few Euros more

	Manufacturer's Specified value.	Meets Eutelsat Requirement?
Input Frequency Range **Low Band:** **High Band:**	 10.7 GHz ~ 11.7 GHz 11.7 GHz ~ 12.75 GHz	Yes
Output Frequency Range	Low Band: 950 ~ 1950 MHz High Band: 1100 ~ 2150 MHz	Yes
Output Connector Type	75 Ohm Female Connector	
Output VSWR	2.0 : 1 (Max.) @ 20°C	Better than Cambridge lnb.
Local Oscillator **Low Band:** **High Band:**	 9.75 GHz 10.6 GHz	Yes
L.O. Frequency Stability	±1 MHz(Max.) ±3 MHz(Max.) @ - 40°C ~ + 60°C	Yes, better than Cambridge lnb.
L.O. Frequency Phase Noise **(@ Room Temperature)** 1 kHz 10 kHz 100 kHz	 - 50 dBc/Hz (Max.) - 75 dBc/Hz (Max.) - 95 dBc/Hz (Max.)	Yes, possibly better than Cambridge, as these are maximum values.
Conversion Performance **Conversion Gain**	 55 dB (Typ.) 60 dB (Max.)	Yes, better than Cambridge lnb.
Gain Flatness **(across operating band)** **(across any 26MHz segment)**	 5 dB p-p (Typ.) ±0.5 dB (Typ.)	Yes
1dB Gain Compression	5 dBm (Typ.)	Meets the Prof.'s Criteria.
Noise Figure **Low Band:** **High Band:**	 0.6 dB (Typ.) 0.6 dB (Typ.)	Not in Eutelsat spec. same as Cambridge lnb.
Image Rejection	45 dB(Min.)	Not in Eutelsat spec.
Cross Polarisation Isolation	25 dB (Typ.) 20 dB (Min.)	Not in Eutelsat spec. possibly better than Cambridge lnb.
DC Current Consumption	110 mA (Typ.)/150 mA (Max.) for AP8-TW	Yes
Operation Voltage Vertical: Horizontal:	 11.5 ~ 14 Vdc 16 ~ 19 Vdc	Yes
Band Switching Low Band: High Band:	 0 Hz 22 ± 4 kHz	Yes
Operating Temperature Range	- 40°C ~ + 60°C	Not applicable
Storage Temperature Range	- 55°C ~ + 80°C	Not applicable
Spurious Response 1700 MHz	- 57 dBm (Max.)	No (almost good enough) Not specified for Cambridge lnb.

Spending a little more money does apparently get us a slightly better lnb, there's more gain, the frequency stability is a bit better, *but the noise performance is about the same*. Perhaps this would be a better lnb for searching out weaker MCPC channels on a weaker satellite (such as Sirius in the UK).

What is interesting here is the spurious signal response measured at 1700 MHz. This says nothing about what the spurious signal level at other frequencies might be, but it is claimed to be a maximum (worst case) figure, so perhaps the one *you* buy will be significantly better than this. The Cambridge lnb makes no mention of the spurious responses in its spec so it seems reasonable to assume that it can be no better than the MTI lnb, and very likely worse in this respect.

What happens if we spend a lot more money?

Here are the specs for the Invacom TWH-031 lnb - it's not cheap!

	Manufacturer's Specified value.	Meets Eutelsat Requirement?
Input Frequency **Low Band** **High Band**	 10.7 - 11.7 GHz 11.7 - 12.75 GHz	Yes
Output Frequency **Low Band** **High Band**	 950 - 1950 MHz 1100 - 2150 MHz	Yes
Noise Figure	0.3 dB typ	Not in Eutelsat spec.
Gain	50 - 60 dB	Yes
Gain Ripple **in 26 MHz bandwidth** **Low Band** **High Band**	 <+/-0.5 dB <5 dB typ <5 dB typ	Yes
Local Oscillator Frequency **Low** **High**	 9.75 GHz 10.6 GHz	Yes
Local Oscillator Phase Noise (typ) **1kHz** **10kHz** **100kHz**	 -65 dBc/Hz -95 dBc/Hz -110 dBc/Hz	Yes, much better than Eutelsat spec.
Local Oscillator stability (including Setting, aging and temperature drift)	+/-1 MHz typ +/-2 MHz max	Yes, better than MTI or Cambridge.
Current Consumption	190mA typ	Yes
Image Rejection	>40 dB	Not in Eutelsat spec. Worse than MTI.
Cross Polar Isolation	>20 dB	Not in Eutelsat spec, same as MTI
High to Low Band Isolation	>25 dB	Not in Eutelsat spec - could be better.
Two Tone 3rd Order intercept point (output)	>15 dBm	Meets the Prof.'s criterion.
Output Connector	2x female F-Type	Yes
Impedance	75 Ohm	Yes
Return Loss	>10 dB	Yes
Operating Temperature Range	-40°C to +70°C	Not in Eutelsat spec.
Storage Temp Range	-40°C to +70°C	Not in Eutelsat spec.

Band Polarization Selection **Vertical Polarization** **Horizontal Polarization**	 11.5V to 14V 15.5V to 19V	Yes
High Band Selection (22kHz tone) **Frequency (square wave with controlled rise/fall transition time)** **Level** **Transition time** **Duty Cycle** **Load Impedance at 22kHz**	 18 kHz - 26 kHz 0.4 Vpp - 0.8 Vpp 5µs -15µs 40% - 60% >70 Ohm	Yes
Low Band Selection	No tone	Yes
In Band Spurious (primarily 1700MHz)	<-65 dBm	Yes
Out of Band Spurious (primarily 850MHz)	<-45 dBm	Not in Eutelsat spec.
Output Gain Difference (between the outputs in 26MHz Bandwidth)	<6 dB	Not in Eutelsat spec.

Spending the extra money appears to buy something, but you do not get more gain than the MTI lnb gives you, and the noise factor, though lower, will not make much, if any, difference to the weak signal capture abilities of your receiver. The local oscillator frequency stability is better, and the phase noise is much lower, so if you are interested in winkling out those SCPC feeds, then this should give you a much better chance.

It *is* a lot of money, however, and if your interests are with MCPC broadcasts from the weaker satellites, then buying a bigger dish would certainly seem to be the better solution.

Summary

Expensive lnbs do have something to offer the enthusiast, but for most people they aren't necessary.
The golden rules are:

1. Read the specification sheet, and know what it's telling you - and what it might be trying to hide.
2. If there isn't a spec sheet available, be very careful. There are plenty of lnbs about that do have a meaningful specification sheet, which will give you some idea of the performance you can expect.
3. Noise figures are only a part of the story, and, according to Eutelsat, they aren't even relevant!
4. A bigger dish is a better solution for most people who have reception difficulties.