EXPERIMENTAL SETUP FOR CONTROL, REGULATION AND SET UP OF OSCILLATOR FREQUENCIES IN LNB CONVERTERS

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Abstract

The article discusses problems arising in the low noise block (LNB) satellite communications converters and their solution. An experimental setup for establishing the oscillator frequency according to the standard values specific to the different types of LNB converters: Singleband, Dualpol, Universal (Single, Twin, Quad, Quattro) is proposed. The experiments were applied for control, regulation and set up of the frequencies of the local oscillators for the low (9750MHz) and high (10600MHz) Ku band range but they can be equally applied to other types of LNBs operating in different frequency ranges. In the experimental setup, no additional generators, emitters, polarizers and feedhorns are used, but only a level meter with a built-in spectrum analyzer with a working frequency band up to 2150MHz. As a source of radio signals for a specific range and polarization, transponders from satellites located on geostationary orbit are used.

1. INTRODUCTION

The reception of satellite signals (TV, R, Internet) is performed with individual and collective (SMATV, CATV) systems. Two satellite ranges are mainly used:

- C (3,4-4,2)GHz;
- Ku (10,7-12,75)GHz.

In recent times the Ka band (17,2-22,2) GHz also finds wider application in VSAT systems. Due to the high values of the radiofrequencies (RF) f_{sig} and their high decay in the coaxial transferring media, it is necessary for frequency of the signals from the satellites to be converted to a lower frequency range and then to be transmitted through a coaxial cable to the receiving equipment (set-top-box, TV receiver, Head End, etc.). The devices, that are used for this purpose are mounted in the focus of the satellite antenna (Dish-parabolic, offset) and are called Low noise block converter (LNB) or Low noise converter (LNC). In some literature sources [1, 2, 3] the name Low noise block downconverter (LNB, LND) is also used. Its main purpose is to amplify the received signals and to convert their frequencies to a lower frequency range IF1=(950-2150) MHz. The frequency converter (DwC) is essential part of LNB and consists of local oscillator and mixer to whose output the filter is connected to.

During normal use of LNB due to different reasons, changes in their technical parameters or defects occur, which make its functioning impossible. Most characteristic are:

- causing defects in the semiconductor elements (transistors, diodes, integrated circuits), resistors and conductors due to penetration of moisture and water, as well as static electricity;
- change in the location of the dielectric resonators, caused by peeling off of the PCB;
- blockage of the waveguides with nests of invading insects (most often wasps) through a pierced plastic cap of the feedhorn (Fig.1).

Figure 1. Plastic cap of the feedhorn

A number of these defects can be removed, but this requires LNB to be disassembled and the defective elements to be replaced. In any such case the oscillator frequency f_{osc} is changed in narrower or wider borders like ±2MHz, ±7MHz, ±10MHz and even more than ±30 MHz. After disassembly of LNB and removal of the defect, assembly follows, but to the extent that adjustment of f_{osc} is possible.

2. STRUCTURAL DIAGRAMS OF LNB

The every LNB contains single-step, double-step or triple-step Low Noise Amplifier (LNA), local oscillator, mixer, integral stabilizer (most often 78xx) and filters.

In the more complex/multifunctional LNBs (Twin, Quad, …) are also electrical switches/multiplexers integrated for provision of same signals in every output (Fig. 2).

The other type of LNB (Quattro), which is used in the collective systems [4] is with four outputs, where the manufacturer decides the arrangement of the signals by polarization and subband (Table 1).

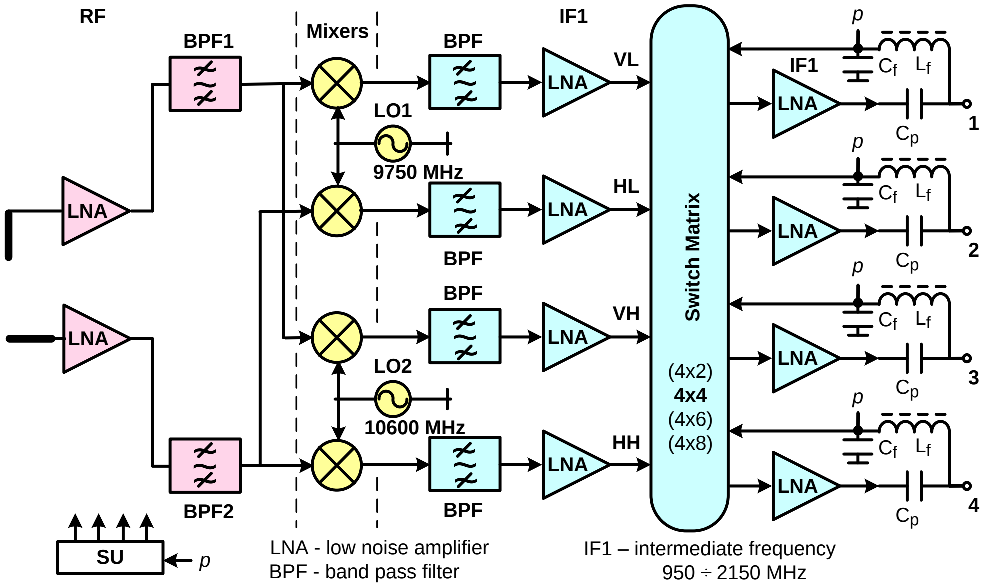

Figure 2. Block diagram Quad LNB

Table 1. Pins for Quattro LNB

Band	Sub band	Polarization	
		Horizontal	Vertical
Ku	Low	HL	VL
	High	HH	VH

The active and passive electronic elements (transistors, resistors, capacitors, inductances, etc.) for processing of the signals from every subband are mainly on separate printed circuit boards (PCB), but there are also such that exist on one PCB.

Regardless of the type of LNB, the oscillators are realized with bipolar or field transistors with parallel or series feedback, that are most often connected according to common emitter/sours scheme [5, 6], where their transit frequency must satisfy the condition:

$$f_T > 2f_{osc}, \text{[GHz]}. \quad (1)$$

The frequency of the output signal IF1 in the modern universal LNB is from 950MHz to 2150MHz and is derived from the following equation [7]:

$$IF1 = f_{sig} - f_{osc}, \text{[MHz]} \quad (2)$$

where for the low subband IF1 = (950-1950) MHz and for the high subband IF1 = (1100-2150) MHz.

For LNB, that work under 8GHz, i.e. in C range [7]:

$$IF1 = f_{osc} - f_{sig}, \text{[MHz]}. \quad (3)$$

The oscillator frequencies are standardized for:

a) Ku band:

- Singleband and Dualpol LNB, f_{osc} = 10 000 MHz;
- Universal LNB, $f_{osc, Low}$ = 9 750 MHz and $f_{osc, High}$ = 10 600 MHz;

b) C band:

- Singleband and Dualpol LNB, f_{osc}=5150 MHz.

Note 1: There are also other values of the oscillator frequencies, but they are used less often. In some satellite receivers there is a possibility for input of arbitrary values of f_{osc}, (Fig. 3).

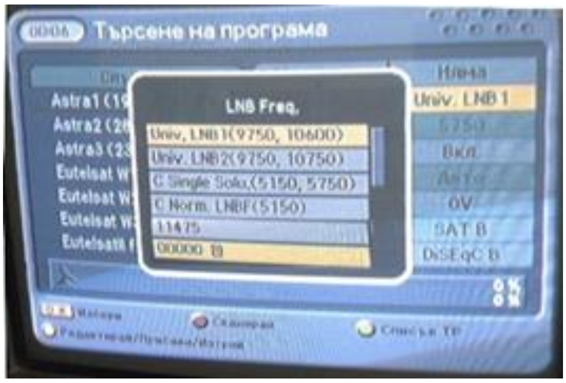

Figure 3. Menu of DVB-S set-top-box

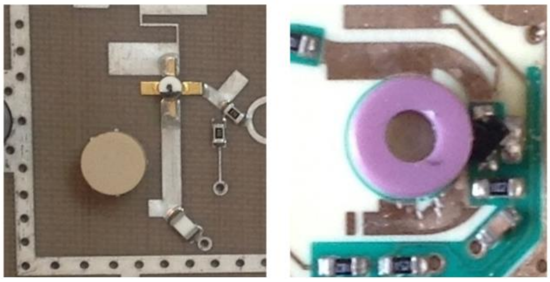

Figure 4. Dielectric resonator (DR)

The main frequency setting element in the classical oscillators is the dielectric resonator (DR), (Fig. 4). Its resonance frequency in the general case according to the equations of Maxwell in TE_{mnp} mode is defined according to the formula [1, 8, 9]:

$$f_r(TE_{mnp}) = \frac{c}{2\pi\sqrt{\mu_r\varepsilon_r}}\sqrt{(\frac{X'_{mn}}{r})^2 + (\frac{p\pi}{h})^2}\quad , \qquad (4)$$

where

$c = 3.10^8$ m/s;

m, n, p – the number of variations in the standing wave pattern in the x, y, z directions;

x'_{mn} – extrema of Bessel functions of first kind;

r – radius DR;

h – height DR;

ε_r – the DR's material dielectric constant;

μ_r – the DR's material magnetic constant, $\mu_r = 1$.

The oscillators in LNB work on TE_{011}. After the corresponding conversions and observing the border conditions for the oscillator frequency with precision of 2%, the following formula is derived:

$$f_{osc} = 374.\frac{r^2}{\sqrt{\varepsilon_r}}.(\frac{2,7}{\pi^2} + \frac{h}{r}).\frac{1}{V}\quad , \qquad (5)$$

where

$30 < \varepsilon_r < 50$ and $2 > (h/r) > 0,5$;

$V = \pi.r^2.h$ – volume of the resonator.

With lower acceptable precision (5-10%), equation (5) can be written as:

$$f_{osc} = 73.\frac{\pi}{\sqrt{\varepsilon_r}}.\frac{1}{\sqrt[3]{V}}\quad . \qquad (6)$$

<u>*Note 2*</u>: By *r* and *h* in [mm] f_{osc} is in [GHz] and by *r* and *h* in [m] f_{osc} is in [MHz].

In practice, the precise ascertainment of the oscillator frequency is done by changing the volume of DR (most often with change of its height) through a metallic screw mounted on the metal screen around the oscillator (Fig. 5).

Figure 5. LNB inside (high subband)

3. EXPERIMENTAL SETUP AND RESULTS

3.1. Description of the experimental setup

The experiments were performed according to the scheme of the experimental setup (Fig. 6) with Universal Quattro LNB, in which the processing of the signals for every subband is done on separate PCB (Fig. 5 High and Fig. 7 Low). The satellite signal from the antenna with LNB separates in two through a splitter, where a combined measuring device (level meter with integrated spectral analyzer) with maximal work frequency of 2150 MHz is connected to one of its outputs, while to the other – a satellite receiver (DVB-S/S2 set-top-box). On the screen of television receiver (TV) are illustrated the menu, submenus and the image of the received channels from the satellite using the satellite receiver.

Figure 7. LNB inside (Low subband)

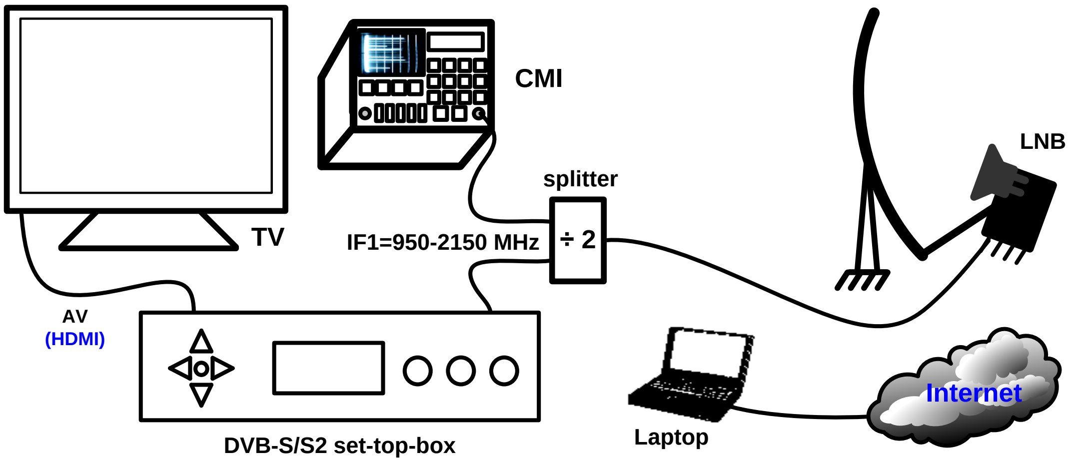

Figure 6. Experimental setup

The connection between TV and set-top-box is through AV cable or HDMI cable. Before starting of the essential part of the experiment, it is necessary for the parameters of the transponders from the satellite, to which the antenna is preconfigured, to be inputted in the set-top-box. For this goal information from www.lyngsat.com is used.

At the beginning (first stage) LNB is with the original settings of the oscillator frequencies and the measured values are presented in Table 2. After that (second stage) it is disassembled and then again assembled. New measurements are performed and the data is filled again in Table 2. In the third stage LNB is again disassembled, but with ungluing/gluing of the dielectric resonator and desoldering/ soldering of the oscillator transistor. The results are given in Table 2.

Table 2. f_{osc} for LNB

	f_{osc}, MHz	
standard	9750	10600
original	9752	10603
new	9750	10600

Note 3: The whole experiment is performed in one day under the same weather conditions for the same transponders in Low and High subbands for the two polarizations (H and V).

3.2. ALGORITHM FOR SET UP

According to the scheme of the experimental setup, when the experiment is carried out (the three stages) it is necessary to perform the following algorithm for the correct set up of the f_{osc} (Fig. 8):

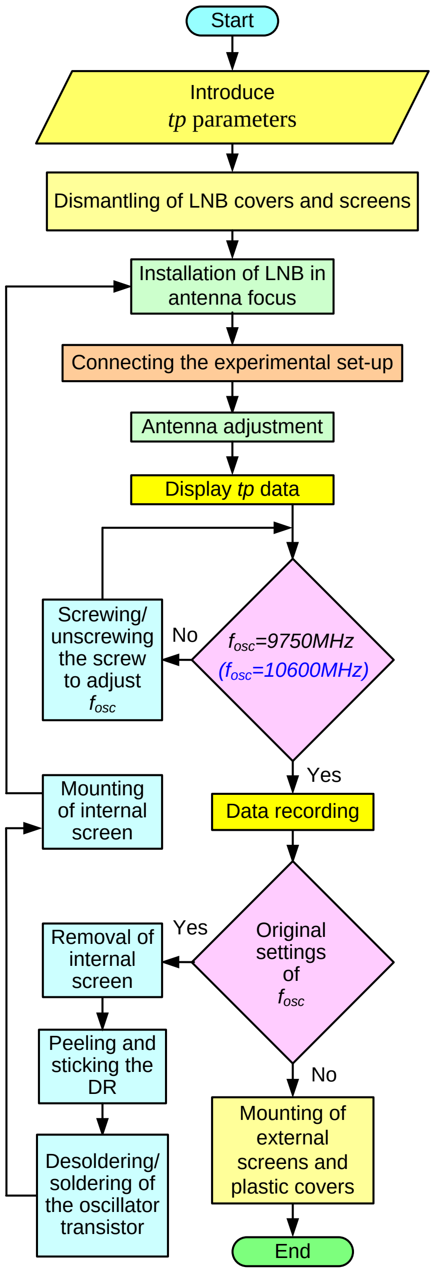

Figure 8. Algorithm

1) Disassembly of the plastic caps and metal screens, in order to reach the screws for adjusting the height and volume of the DR and respectively of f_{osc} for every subband.

2) Mounting of LNB in the focus of the antenna.

3) Connection of the experimental setup from Fig. 6.

4) Orienting the antenna to preselected satellite. For its precise setup (by azimuth and elevation), the measurements of the combined measurement device in spectral analyser mode and the TV, where the main parameters of the satellite signals are visualized, are watched (Fig. 9). After the appearance on the TV screen of the maximal values of the level and quality of the signal for a specific transponder, all screws and nuts are tightened.

<u>*Note 4:*</u> The transponders for the specific satellite are chosen in advance and the data for the frequency, polarization, speed of symbols (SR) and f_{osc} are entered. Supply voltage to the LNB is permitted.

5) The data is read and written in Table 2.

6) The screen for Low and High subbands are successively disassembled. In the third state, the DR is peeled/glued, and the oscillator transistor is desoldered/soldered. These operations require the disassembly and, again, assembly of the LNB from and to the holder of the focus of the antenna. After the procedures in the second and third stages, the screens with the screws for the regulations of the oscillator frequencies are mounted.

7) Power is provided to the LNB, according to the experimental setup, successively for every output (respectively polarization and subband).

<u>*Note 5*</u>: In the same way are the checks and adjustment of f_{osc} performed for the other subbands and polarizations.

8) LNB is demounted from the antenna, the external screens and plastic caps are mounted.

9) LNB is mounted in the focus of the antenna again and verification of the values of f_{osc} for each subband is performed.

<u>*Note 6*</u>: If necessary, the operations from 1 to 9 are repeated (the author in his practical activity has not had so far such problem).

3.3. Experimental results

From the measured data (Table 2), it can be seen, that for Low the oscillator frequency has changed with around 2 MHz and for High – with around 3 MHz. The placement of the screw for regulation of the height of the DR is presented on Fig. 7: 1- initial position at original setting and 2- new (after the set up).

On Fig. 9 and Fig. 10 shows the spectrograms and bargraphs respectively at $f_{osc} \neq 9750$ MHz and after tuning with the screw $f_{osc} = 9750$ MHz.

Figure 9. $f_{osc} \neq 9750$ MHz

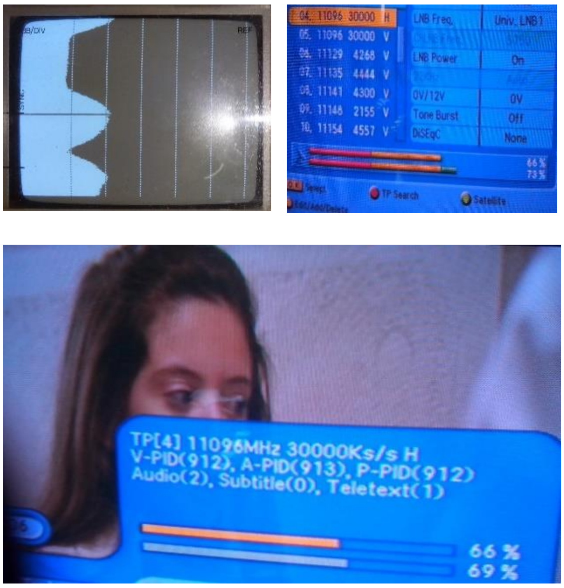

Figure 10. $f_{osc} = 9750$ MHz

It is clear that at f_{osc} different from the standard values there may be an indication of the presence of a satellite signal, but the quality is low, which is due to the high BER values before and after the error correction due to the low values of C/N < 6,5 dB [10].

After application of the described method for precise set up of the oscillator frequency, the quality of the channel rises from 16% to 69%-73%, which allows proper reproduction of the satellite signal and the appearance of quality image (Fig.10) and sound.

4. CONCLUSION

The suggested method and the described algorithm can be applied to all types of LNB converters, whose oscillator frequencies are obtained with DR oscillator (DRO). In this paper, the case where both oscillator frequencies are higher than the standard was investigated. They can be applied with the same success also when one f_{osc} is lower (e.g. 10597MHz), and the other is higher (e.g. 9764MHz) or both f_{osc} are lower (e.g. 9743MHz and 10540MHz). After disassembly and subsequent assembly of LNB, it is necessary to pressurize its housing for protection from penetration of water, moisture and dust.

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