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Analysis of the transposition of frequency and itsfidelisation: application to aFrequency Modulation radio channelin Lubumbashi, DRC

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Abstract

The study aimed to study the selectivity of the frequency of a signal emitted by a broadcasting station in frequency modulation (FM). The measurements and analyzes were made using Persian and Spectrum Analyzer in the laboratory of the Regulatory Authority of Posts and Telecommunication of Congo (ARPTC). This study synthesized measurements and spectral analyzes made on the various FM radio channels of the city of Lubumbashi. The observation made reveals that some local channels do not respect the frequency excursions and the bandwidths allocated to the frequency modulation; this is particularly the case of Tam-Tam radio station in Africa. Thus, in this work, we proceeded by measuring the transmission frequency of the aforementioned radio station, and its spectrum delimited by the bandwidth. The analysis of the bandwidth of Tam-Tam radio in Africa shows an expansion of its spectrum, whose bandwidth is 500 kilohertz, instead of 300 kilohetz, as recommended in FM, with the consequence of jamming stations located immediately to the left and to the right.

Keywords:

Frequency transposition,
FM radio, Clean frequeny

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1. Introduction

The role of a telecommunication system is to transmit information between different users and allow them to interact (Arneaud, 2006). The convoy of information can not be done directly on the transmission media. Hence, the need to implement modulation techniques to adapt the information signal to the transmission medium. The useful signal (low frequency) to be transmitted is then used to modulate the carrier (high frequency) of determined shape and frequency more adapted to the channel and the transmission mode (Redoutey, 2009). The signal transmission is done in two steps (Van Droogenbroeck, 2013):

The modulation of one of the parameters (phase, frequency, amplitude) of the carrier signal at an intermediate frequency;

- Then the modulated signal goes into a mixer to be transposed to high frequencies. Assuring the transposition function, the mixer is a device for frequency transposing a signal without changing the information it carries. After transposition, two new frequencies are generated as the sum (fo + f1) and the difference of two first ones (fo-f1); these two frequencies constitute the sidebands of the modulated wave. Each of two frequencies (sum and difference) carries useful information. By filtering, one of the two frequencies is selected to be transmitted, while the other must be stopped or eliminated (Jebri, 2002). The transmitted signal must have a working frequency equal to the transmission frequency and with good selectivity to retain the transmission. In the case of the present study, the fact is that the radio Tam-Tam of Africa emits on two different frequencies to know; 88.09 and 88.303. Megahertz, which causes the spreading of its bandwidth. By a technical and scientific approach, propose that a single frequency be used in order not to create interference with neighboring stations.

2.1. Study area

This study was conducted in Lubumbashi, capital of the province of Upper Katanga in the Democratic Republic of Congo. Lubumbashi, is located at 11 ° 40' latitude and 27 ° 29' longitude. Lubumbashi is confronted with multiple problems of water and electricity cuts due to the dilapidated infrastructure and sometimes the cost of the subscription to REGIDESO (company in charge of water distribution in DR Congo) and SNEL very high. From the point of view of the growth of urban space and habitat dynamics (Bruneau, 1987), Lubumbashi is considered as an exploded city from a new population explosion, under the double influence of natural growth and a migratory balance supported by the exhilaration of copper price-caps (Nsiami, 2009). Frequency measurements and spectrum analyzes were done at ARPTC.

2.2. Methods

Band scanning has three main objectives: verification of spectrum availability before assignment, the occupancy control and identification of users and the prevention of frequency interference or malfunctions

In broadcasting, the strong growth of local radio stations requires special monitoring of the occupancy of the FM radio band at least once a month. It is with this in mind that we conducted our analyzes at the ARPTC.

In order to detect the disturbances that occur on the FM band, the verification tests were carried out using the following devices: the spectrum analyser and the Persian.

Frequency measurements focused on spectrum scanning by frequency sweeping. The spectrum occupancy checks make the Object of a programming according to the type of band (HF, VHF, UHF) and the service (terrestrial service, maritime mobile service, aeronautical service and broadcasting service) (ARPTC 2014).

3. Results and discussion

Measurements made using Persian and Spectrum Analyzer allowed us to elaborate in a non-exhaustive way the table 1.

Table 1. Measurements with Persian and Spectrum Analyzer

Channel	Assigned frequency in MHz	Meseared frequency in MHz	Signal level in dBm	Assigned bandwidth in KHz	Measured bandwidth in MHz	Observations
Malaîka	87.5MHz	87.515	-60	300	0	OK
Dynamique	87.8MHz	87.818	-56	300	0.303	OK
Tam-Tam Afrique	88.0MHz & 88.3MHz	88.09 & 88.303	-47.1 & -62	500	0.722 & 0.485	The spectrum expands more
Reva	88.5	88.503	-68	300	0.2	OK
Mwangaza	89.0MHz	89.004	-62	300	0.501	OK
Eben-Ezer FM	89.2MHz	89.223	-55.2	300	0.219	OK
Kyondo	89.5MHz	89.504	-42.1	300	0.281	OK
Umoja	93.4	93.496	-25	300	0.58	OK
RTNC	94.4	94.481	-54	300	0.47	OK
Okapi	95.8	95.827	-56	300	1.34	OK
RFI	98.0	98.018	-53	300	2.002	OK

It was by observing the frequency band at the Spectrum Analyzer and the Persian that we found that the spectrum of the Tam-Tam radio spreads further by going far beyond the bandwidth allocated for broadcasts. in FM which is 300KHz, it approaches a width of nearly 500KHz and it presents the problem of fidelity in frequency (its frequency is not stable at any moment, it fluctuates in the interval of [88.0 to 88, 3]).

This causes problems of interference and interference frequencies of neighboring channels among others, the Dynamic radio (left station at 87.8 MHz) and radio RTIV (right station at 88.2 MHz).

The previous table does not show the measurements and analyzes of Radio-Inter Viens et Vois (RTIV), because it is blurred by the very wide spectrum of Tam-Tam radio in Africa, hence the difficulty for measuring devices, to detect and analyze the spectrum of the RTIV. The following figures show the measurements made by the spectrum analyzer on the bandwidth of Tam-tam radio in Africa, and we note the widening of its spectrum which interferes with the frequencies situated on both sides of its spectrum. frequency.

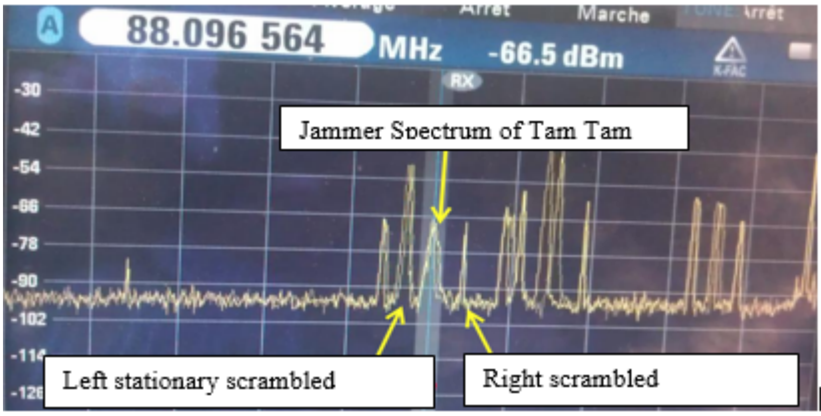

Figure 1. Local channels scrambled by the spectrum of radio station Tam-Tam Africa

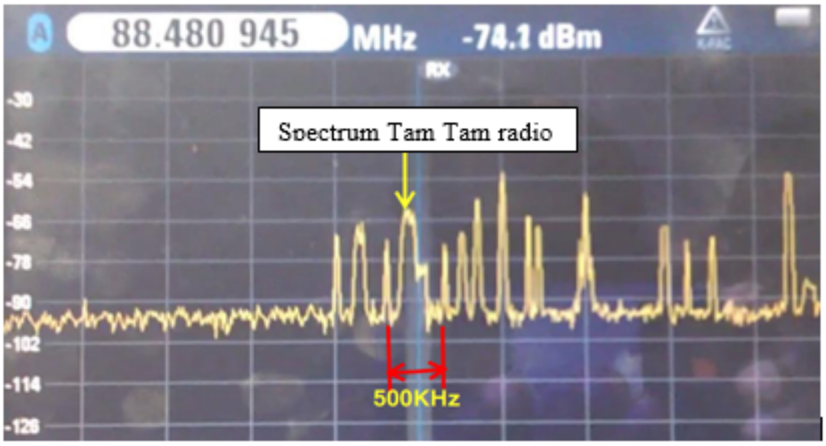

Figure 2.spectrum of radio station Tam-Tam Africa

To allow the selectivity of the carrier wave of the radio signal Tam-tam Africa, we suggest to assign it the frequency of 88.0MHz. Thus, the allocated bandwidth will occupy the frequency range of 87.85MHz and 88.15MHz, an interval of 300KHz, as prescribed by the standard in frequency modulation.

In order to obtain a good transposition of frequency, we propose the following structure for a good fidelity and a better selectivity. Structure of an FM production line

The figure 3 gives the model that we propose for an FM channel that can selectively transmit and an allowable frequency deviation in frequency modulation.

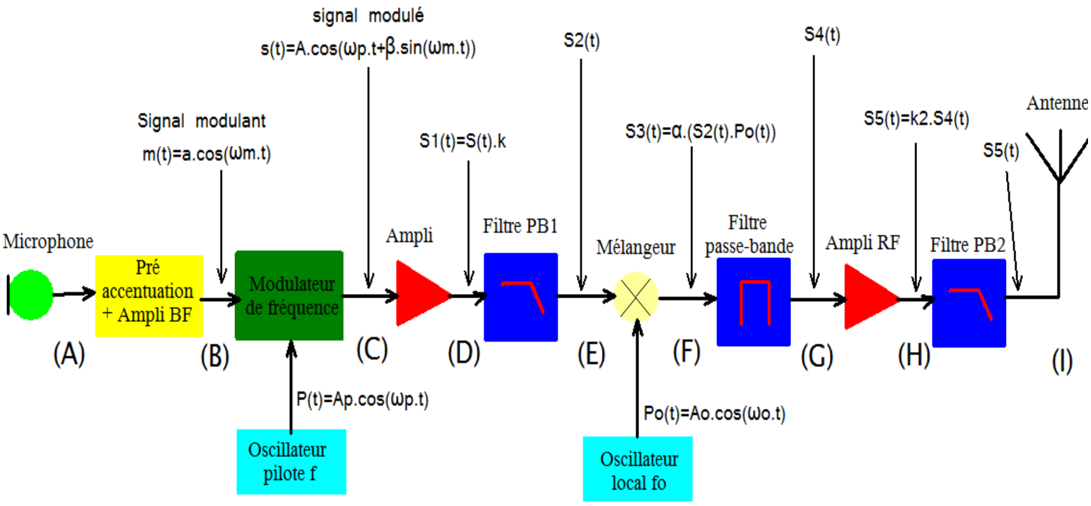

Figure 3. Detailed structure of the FM transmitter

3.1. Frequency analysis of FM (Tam Tam Radio) production channel

The wanted signal experiences several kinds of disturbances throughout the transmission chain. These disturbances are generally called noise. To do this, the signal produced undergoes several treatments that allow the latter to be well conditioned to eliminate all disturbances. To do this, we will perform a frequency analysis of all stages of the FM production chain. In the model proposed in Figure 9, we have:

(I) dipole-type transmit antenna stage at f=88.0MHz ;

(H-I) low pass filter for signal fidelity at f_p=88,0MHz ;

(G-H) RF power amplifier;

(F-G) band pass filter to clean up harmonic at f_0=88,0MHz ;

(E-F) mixer, we find the following equations

$$f_3 = f_2 + f_0 \quad \text{Avec} \quad f_3 = 88{,}0MHz$$

$f_0$is the frequency of the local oscillator, it is 88.0 The spectral representation of the signal coming out of the mixer is as follows:

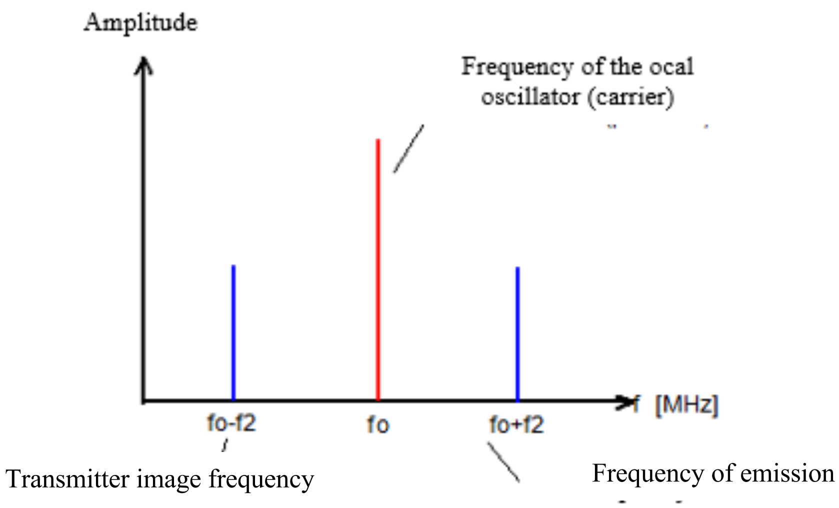

Figure 4. Spectral representation of the signal at the output of the mixer

3.2. Synthesis of the harmonic filter

The use of operational amplifiers and other active components as well as the transposition of frequencies cause the generation of harmonics which make the transmission of signals unpleasant (DesmouliereandChevillard, 2004; Dieuleveult et al. 2008). To overcome this, the signal requires appropriate treatment. This is how the synthesis of two passive filters; a low pass and a pass band, proves judicious for our study.

The role of each filter is:

- For the low pass, allow to eliminate or attenuate all the harmonics that are multiple of the fundamental frequency.

- The band pass filter is inserted at the output of the mixer, to select the sum frequency.

For the design of the guard filters of this chain, the passive components (capacitors and inductance) will be used because the active components (operational amplifier) have:

- A reduced bandwidth, which makes their uses limit or not even used for audio applications;
- The amplitudes of the signals that can be processed by active filters are of the order of the Volt (beyond this value, they can produce distortion);
- Resistors and operational amps produce noise.

On the contrary, passive components are used for high frequency applications (up to 500 MHz). The bandpass filters proposed, will be calibrated according to these values, to provide the signal of our station, selectivity and loyalty during modulation (Teston, 2006; Koeniguer, 2009). Because, as shown by the instability of the oscillator and the lack of selectivity of the filters cause a spread of the bandwidth at 500KHz, instead of 300KHz, as recommended for the FM band.

Conclusion

The purpose of this work was to establish a precise frequency for Tam-tam Afrique radio station. To achieve this, we have resized the filters and oscillators according to the specifications. This makes it possible to obtain a good fidelity of the signal to be emitted, in order to avoid the problems of interference of the neighboring frequencies. These sizing is done according to the frequency of Tam-Tam Africa radio, set at 88.0MHz. The low-pass filter is calibrated to attenuate the signal above 80.15MHz and the bandpass is set to transmit the band 300KHz or 87.85MHz at 80.15MHz. Thus, Tam-tam Africa will no longer interfere with the two stations located on either side of frequency, in this case, the Dynamic radio (87.8) on the left and the RTIV (88.2) on the right. Regarding the realization of the filters, we can use the model of Butterworth or Tchebytchev, because their templates have a good selectivity, which will allow the loyalty of the working frequency.

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