NOISE MEASURING IN TV CHANNEL

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Abstract: This paper presents the experimentally results of noise measuring at TV receiver entrance. The experimentally measurements were concentrated onto determining the characteristics of the noise in UHF frequency band TV channels. The data acquisition system was used to measure various parameters of fluctuation noise at TV receiver input. These parameters are important in understanding the noise influence on the quality of received images and for selection radio channels which permissive optimum radio links.

Key words: TV channel noise, communications system noise.

1. INTRODUCTION

The TV channel establishes the one-way connection between the transmitter and the TV receiver, being destined for video and audio information carrier signals transmission. Usually, by TV channel we understand only the part allocated for video signals, the sound being independently transmitted on a radio frequency carrier *fps,* having its frequency greater than *fpi,* the image carrier.

The physics of noise are based on the material particles movement, which generates electrical free oscillations. The radio receivers' and TV sounds and images reproduction is perturbed by the oscillations and the magnetic fields produced by atmosphere, planets and galaxies. If we have a good signal – to – noise ratio (SNR) at the TV receiver input, the perturbations effects are reduced, but not totally eliminated, this effect being one of the causes for TV image quality deterioration ([3], [4]).

The noise is a random electrical signal, undesirable, which is superposed over the information signal, modifying it. Its character is completely aleatory, chaotic, because the noise is created from many components, which have random amplitudes and phases. We can measure the noise effective value, but we cannot predict in any moment its amplitude and phase.

From the radio communication system point of view, concerning the transmitting – receiving equipments, the noises can be classified as been internal or external. The external noises are produced by the natural environment or by the human activities. Their power is +15 dB for urban noise (for a large bandwidth), between –5 dB and –50 dB for atmospheric noise (10 – 40 MHz bandwidth) and –45 dB to –35 dB for solar noise (10 – 100 MHz bandwidth).

For the TV spectrum (30 MHz – 1 GHz), the cosmic noise is greater than that produced by terrestrial atmosphere.

The internal noises appear due to the electronic device characteristics, their source being the electric resistance and the semiconductors. This kind of noise can be thermic, flicker (1/f) and pulses noise.

The noises that can be predicted only by averaging, using probabilistic laws, are named ergotic noises (eg. Gaussian noises). A large majority of noises can be considered gaussian, having constant power in bandwidth. The gaussian (fluctuation) noise has a normal probability law (Gauss) with the same distribution in every moment of time and it cannot be rejected using ordinary technical procedures (filtering, limitations).

The equivalent generators of the noise sources can be serial connected and the total noise voltage value for n gaussian sources E_{zgtot} is calculated using the equation (1).

$$\mathrm{E}_{\mathrm{zgtot}} = \sqrt{\sum_{i=1}^{n} E_{zgi}^{2}}\ . \qquad (1)$$

The fluctuation noise from the TV channel produces image quality deterioration, for fine details and contrast. A noisy image on the TV receiver appears due to the noise power and its distribution on the channel frequency spectrum.

The statistical characterization of any kind of noise can be done using the probability distribution function and the power density function. For gaussian noise, the probability density function allows $p(v)$ probability that the perturbation to overtake an amplitude threshold (see Fig. 1). The probability that the instantaneous perturbation value v_i to be overtaken is represented in the figure by the hatched area below the curve. We can calculate this area by solving the integral on the interval viI and v_i+dv. The probability density function is defined by [2]:

$$p(v) = \frac{1}{\sigma\sqrt{2\pi}} \cdot \exp\left(\frac{-v^2}{2\sigma^2}\right); \qquad (2)$$

where: ν - instantaneous value of the noise;

σ - mean squared value (standard deviation) for the noise voltages values given by:

$$\sigma = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(v_i - \mu)^2}\ ; \qquad (3)$$

where: N – the instantaneous measured values number;

v_i – instantaneous measured values;

μ - noise mean value, computed as arithmetic average of the instantaneous measured values, given by equation (4).

$$\mu = \frac{1}{N}\sum_{i=1}^{N} v_i\ . \qquad (4)$$

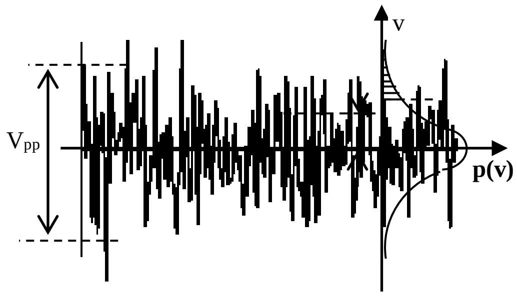


Fig. 1. *Noise level and amplitude normal distribution curve; V_{pp}=(6 – 8)σ.*

2. NOISE MEASUREMENT SYSTEM

For our experiments we have chosen a system based on data acquisition and processing, shown in Fig. 2, where:

- ✓ Aa - antenna amplifier;
- ✓ At - input step attenuator;
- ✓ Card I/O - 16 bits resolution, quantization threshold = 1.22 mV (1 LSB), conversion time A/D = 40 μs, sampling period = 52.8 μs, sampling frequency = 18.9 kHz.

The spectrum analyzer has its own gain G_{Azg} = 20 dB and the circuits for signal conditioning (amplifying, limiting and protection) have G_{cc} = 20 dB.

Excluding the noise analyzer input attenuator; the measurement system has a total gain of 50 dB, calculated using the equation (5).

$$G_{system} = G_{Aa} + G_{Azg} + G_{CC} = 10 + 20 + 20 = 50[dB]. \qquad (5)$$

Performing simultaneously measure-ments on 3 acquisition channels, each of them having 350 samples in the same time interval (33 s), allows noise levels chaining and acquiring an increased number of samples: 3×350 = 1050 samples of noise values.

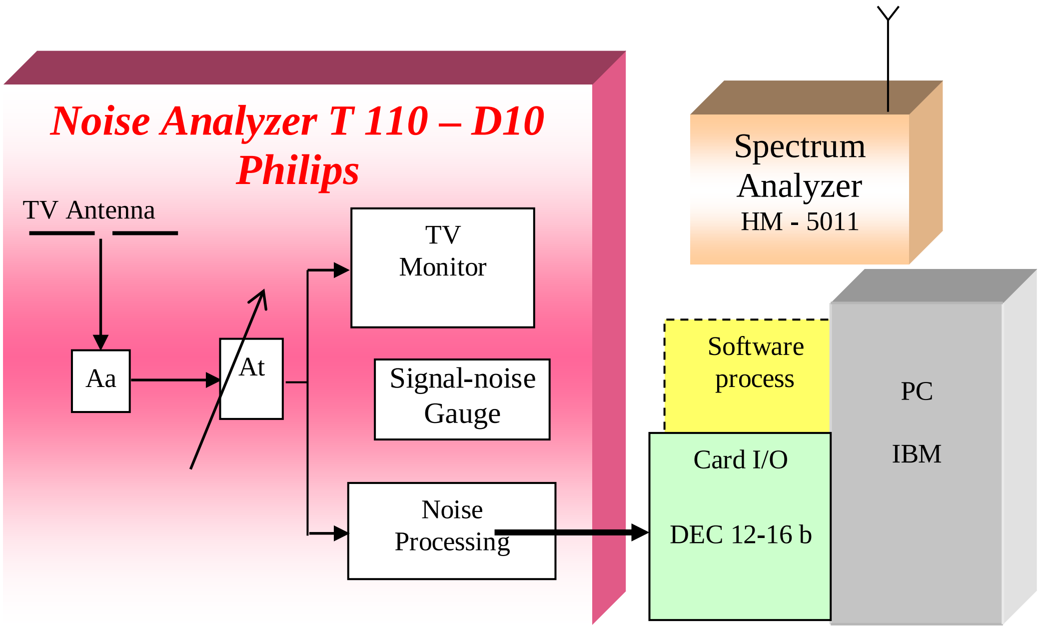


Fig. 2. *The equipment interconnection for noise measurement at the TV receiver entrance.*

3. MEASUREMENTS AND EXPERIMENTAL RESULT

The purpose of our measurements was to:

- determinations on the electro-magnetic field spectrum in TV bands VHF and UHF [1];
- predominant noise character establish, which perturb image quality Q;

determine the noise indicators in different receiving conditions V_M, V_m, V_{VV}, σ, μ, μ_m, *CV*, *TE*, *FR* (see Table 1);

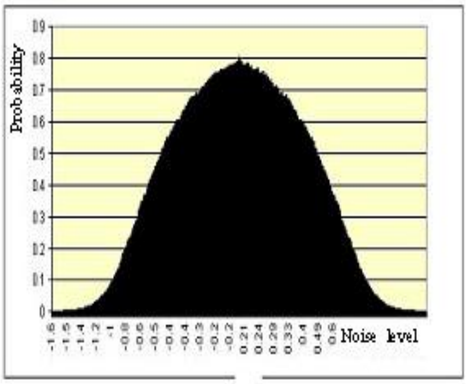
- establish correlation's between the noise characteristics and receiving quality;

The relevant characteristics of RF electromagnetic fields were measured with a spectrum analyzer.

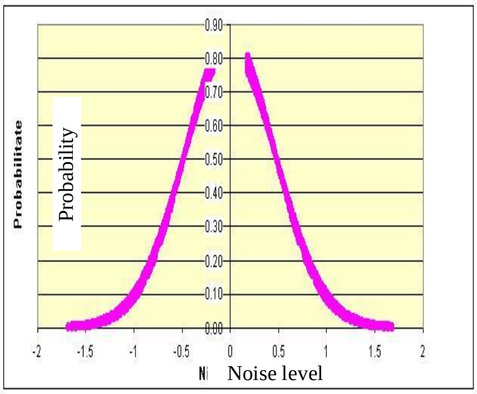
Based on the results obtained in the difference test points various diagrams and spectral representations were made. Using spectral analysis graphs diagrams of radio and TV frequency distribution were made.

The probability histogram representation and the probability distribution Gauss curve drawing can be done through two rows of value realization.

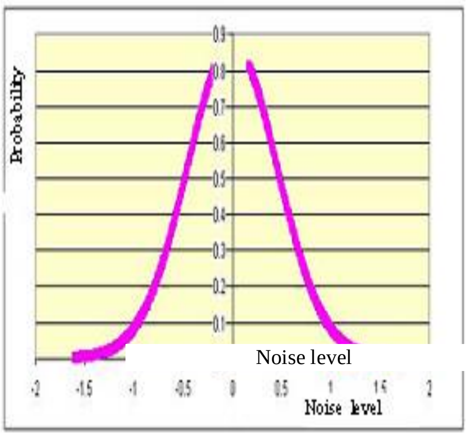
The first row contains the noise levels, having inside 1050 positive values levels, plus 1050 negative values obtained through the sign changing of the positive ones. The second row contains the probabilities corresponding the noise levels row. After decreasing arrangement of the two rows, considering noise levels values, we have represented the histogram and the Gauss probability curve (see Fig. 3 a, b).

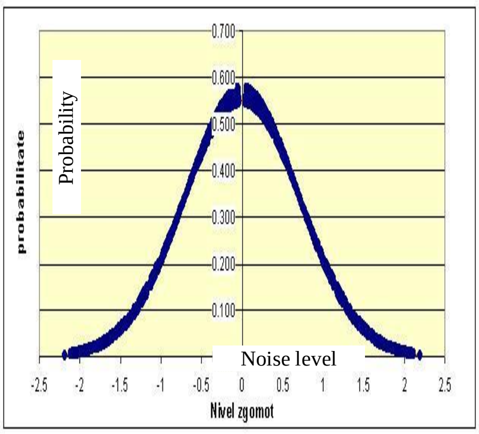


a) *Gaussian probability distribution for 1050 samples.*



a) *TV image "excellent ". Q = 4; Mean value = 0,76; Standard deviation = 0.47*





b) *Gauss curve for 1050 samples. Mean*

b) *TV image "poor ". Q = 2; Mean value =*

value = 0.739; Standard deviation = 0.459..

0,74; Standard deviation = 0.70.

Fig. 3. *The probability distribution Gauss curve for 1050 samples.*

Fig. 4. *Gauss probability distribution curves for 1050 samples*

Applying the same methodology for data processing we have determined the noise indicators values for each channel and for the 1050 samples (see Table 1); increasing samples number means to obtain clearly histograms and small errors.

4. CONCLUSIONS

The first conclusion is the standard deviation controls the width of the bell shape (see Fig. 4).

From the obtained results concerning noise indicators values for 1050 (for good quality image, Q=4 and low level of noise) samples we can conclude:

- the noise characteristic information has a smaller typical error TE (0.014), meaning a good determinations and conclusions accuracy;
- effective (standard deviation) and mean value of gaussian noise are growing to 0.459 and 0.143 units, respectively, in respect to peak to peak noise growing in the same interval;

the big values of the indicators peak factor, variation coefficient and repetition frequency of noises indicate a reception quality deterioration.

Table 1. *Noise indicators values for 1050 collected samples on three channels at the 27 TV channel receiving, for 60 dBμV (- 47 dBm) television signal entrance level*

Noise indicators	Channel 0 350 samples	Channel 1 350 samples	Channel 2 350 samples	Values for 1050 samples
Mean value - μ	0.746	0.743	0.729	0.739
Maximum value - V_M	1.58	1.58	1.6	1.6
Minimum value - V_m	0.2	0.17	0.19	0.17
Peak to peak value - V_{pp}	1.38	1.41	1.41	1.43
Standard deviation (Effective value) - σ	0.460	0.461	0.457	0.459
Gaussian noise average value μ_{av}	0.143	0.142	0.145	0.143
Typical error - $TE = \sigma/N^{1/2}$	0.025	0.025	0.024	0.014
Variation coefficient [%] $CV = 100x\sigma/\mu$	61.68	62.01	62.64	62.05
Peak factor of the Gaussian noise [dB] $FV = \mu_{av}/\sigma$	0.31 -10.18	0.31 -10.21	0.32 -9.97	0.312 -10.11
Repetition frequency of the noise levels - *FR*	3 4 2	3 2 2	2 4 1	3 4 2
Noise level with maximum repetition frequency	0.21	0.23	0.23	0.23
Standard deviation between the noise levels - Δ	0.46	0.46	0.46	0.46

Constant maintaining of the gaussian noise average value (μ_{av} = 0,14) means that the noise has amplitude normal distribution, a constant power in the TV
channel bandwidth where the measurements have been performed (518 ÷ 526 MHz) and can be treated as a gaussian (white) noise.

Focusing our attention on the maximum and minimum noise peak values, on the peak-to-peak variation with 0.04 units and noise arithmetic mean variation with 0.007 units we can conclude, also, that noise from the TV channels is gaussian and its effective value don't cause TV image important deteriorations.

Very importance is the correlation between TV image quality *Q* and noise indicator values:

Noise indicators	Q=5	Q=2
- Maximum value	1.68	2.19
- Peak-to-peak value	1.50	2.15
- Standard deviation	0.47	0.70
- Repetition frequency	2	14

The noise parameters are important in selection radio channels which permissive optimum radio links.

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