SIGNAL-TO-NOISE RATIO METER FOR VIDEO-SIGNALS

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SUMMARY

This paper deals with problems and principles of direct measurement of the signal-to-noise ratio (SNR) for videosignals (in the baseband).Detailed block diagram of designed measuring device and properties of partial functional blocks of this device are described.

Keywords: *measurement, video-signal, noise, noise factor, signal-to-noise ratio*

1. INTRODUCTION

Methods of determination and measurement of the noise factor F of passive or active blocks and elements are well known, while direct measurement of the signal-to-noise ratio is very complicated. This measurement is very important in the video and television technique, because the noise can greatly degradate TV picture. The signal-to-noise ratio in the base-band is defined in the technical literature as the ratio of **powers** of video signal and noise signal SNR = $S/N = P_{Sp\text{-}p}/P_{Nef}$ usually. In contrast of this definition we will considere the video-signal-to-noise ratio Φ_{SNR} as ratio of the **peak-to-peak voltage** $V_{Sp\text{-}p}$ of **luminance** signal and **effective** value (RMS) of the **noise** signal **voltage** V_{Nef} in the next text. Accordingly

$$\Phi_{SNR} = V_{Sp\text{-}p}/V_{Nef} \qquad (1)$$

It holds for this ratio (providing the impedance matching of the all parts of the video tract usually 75 Ω)

$$\text{SNR} = (\Phi_{SNR})^2 . \qquad (2)$$

2. METHODS FOR MEASUREMENT OF THE SIGNAL-TO-NOISE RATIO

International measuring signal No.5 is used 5 for measurement of Φ_{SNR} ususally. This video-signal has constant level in the course of every line (see Fig 1) and its frequency spectrum contains low frequency components only (in the frequency range 0–200 kHz).

Sinal-to-noies ratio Φ_{SNR} can be defined without consideration of visual perception of the observer, as so-called **unweighted** signal-to-noise ratio Φ_{SNR}. It is can be measured **weighted** signal-to-noise ratio Φ_{WSNR} by means of the standardized **videometric filter** (2nd order lowpass filter) in the opposite event Value of Φ_{WSNR} is greather than Φ_{SNR} because it respects less sensitivity of observer for the fine-grained noise in the picture.

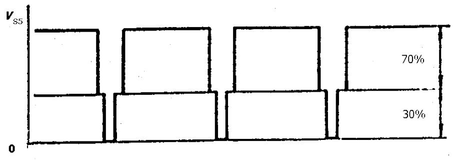

Fig. 1 Time response of the international measuring luminance video-signal No.5 (V_{S5}) for the measurement of the noise

Measurement of Φ_{SNR} can be realized by the:

a) sequential oscillographic measurements of the signal components in the time response (peak-to-peak voltage of video-signal and peak-to-peak voltage of noise). These values are divided. This method is hardly practicable for high values of Φ_{SNR},
b) frequency filtering of the special measuring video-signal with added noise and sequential measurement of signal components (peak-to-peak voltage of the video-signal and efective (RMS) voltage of the noise) in the diverse frequency bands. These components are rectified and divided. This measurement may be realized, because auxiliarry components of the video-signal No.5 (synchropulses, blanking pulses and luminance signal only) are placed in the relatively narow frequency band (cca 200 kHz) against the noise componets. On the contrary this method requires relatively comlicated measusuring device.

Measuring device employed the method b) and controlled by the microprocessor was developed in the Department of Radioelectronics (Faculty of Electrical Engineering and Communication Technologies, Brno University of Technology). Described measuring device makes possible measurement of the unweight signal-to-noise ratio Φ_{SNR} only, because the noise signal is not measured in the whole frequency band of the videochannel. Principle, block diagram and function of this device is described in further text.

3. BLOCK DIAGRAM OF THE METER

Principle of this measuring device is apparent from the block diagram in Fig. 2. Measusured video-signal V_{s5} (positive polarity) with added noise is, after impedance matching (by the emitter folower EF), divided to three frequency different channels. First output excites the lowpass filter LPF. Filter LPF is realised as pasive 3rd order Cauer's filter [3] with the treshold frequency f_m = 200 kHz. Output signal of this block corresponds to the low frequency luminance components of videosignal only. Second output excites (after amplification and inversion of video-signal polarity by the amplifier AI) sync separator SS which generates line synchropulses. These pulses are transformed on the pulses V_k for clamping of the direct-current restorer DCR in the blanking level by means of the block CFP. Third output excites the active highpass filter AHPF in the noise channel. Frequency band of this filter lies outside of frequency spectrum of the measuring video-signal No.5. Filter AHPF is realized as low-noise active highpass filter 4rd order with treshold frequency f_t = 1 MHz and voltage gain G ≈ 60dB. Output signal of this block is practically amplified noise signal (G.V_{Nef}) only. Noise signal must be amplified by the active low-noise highpass filter AHPF, because its level is insufficient for accurate RMS detection by the block RMSD. Peak-to-peak rectifier PPR generates peak-to-peak value of video-signal. Rectified signals $V_{Sp\text{-}p}$ and V_N·G are constant practically. These signals are digitalized by means of analog-to-digital converters ADC1 and ADC2 (8 bits per sample and frequency of sampling f_{samp} = 50 kHz). Reference levels of both converters are equal. Both analog signals are sampled synchronously by means of the pulses V_{samp} generarated by the generator GS. 8 bits output digital signals in the parallel form are connected to the two inputs of microprocessor MPC. This microprocessor realizes these functions especially:

a) digital dividing of two digital signals appropriate to values of signals VSp-p and VNef after the rectification and analog-to-digital conversion,
b) digital multiplication of this ratio by the constant A that is aproximatelly equal to the amplification factor G of the AHPF in the noise channel, because the very small noise signal VNef was amplified before the RMS detection (A ≈ G),
c) digital correction of the own noise of the partial blocks (in the noise signal channel especially) of this meter. This correction is realized by means of the variation of the value of the multiplicative constant A at the final calibration of the meter,
d) generation of control signals for driving of the display DISP with built-in driving circuits.

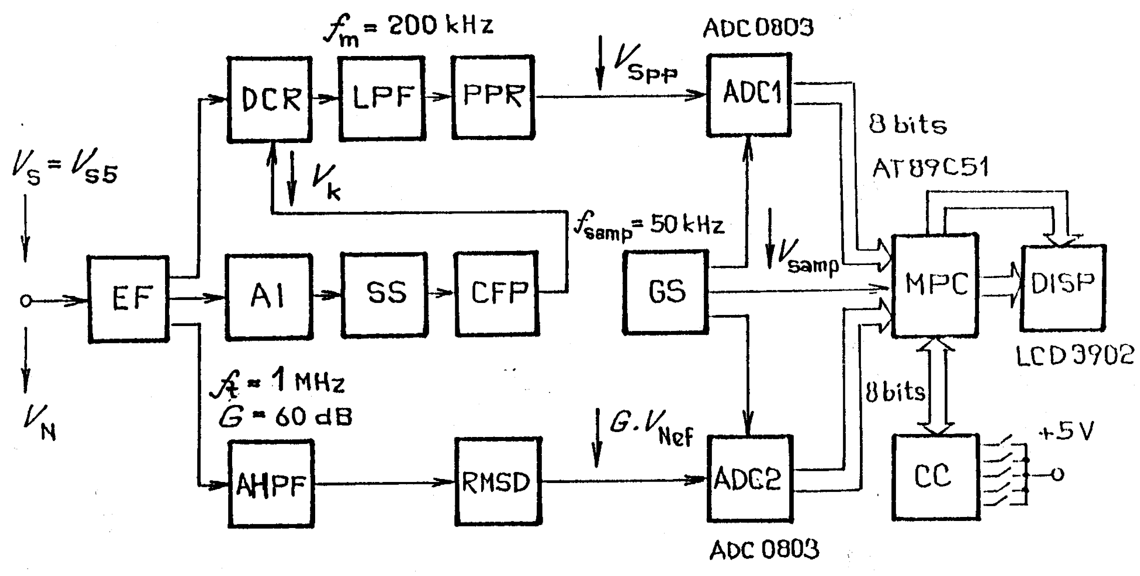

Fig. 2 Block diagram of the video-signal-to-noise ratio meter with microprocessor control

Signification of symbols in Fig. 2

EF……... emitter follower	AHPF…. ..active highpass filter with amplification G
LPF…….. lowpass filter for video-signal	RMSD…...RMS detector
AI……….inverting operational amplifier	ADC1,2....analog-to-digital converters
SS……… sync separator	MPC…….microprocessor
CFP……..circuit for the synchro pulses forming	GS……....generator of sampling pulses
DCR…….direct-current restorer	DISP…….display for measured data
PPR…......peak-to-peak rectifier	CC……….control circuits

Resultant data are displayed in decimal forms by the one line display DISP. This display contains necessary driving circuits in the own integrated chip and it is interconnected with the output of microprocessor MPC by the data bus. Detailed description of the structure and circuit diagrams of partial blocks of this measuring device is beside the thematical scope of this contribution. Integrated circuits used in particular blocks are designated in the block diagram in Fig. 2.

Resultant accuracy of measurement depends on the transfer coefficients stability of blocks of both measuring channels – especially in the channel for the noise signal processing (filtering, amplification and detection in blocks AHPF and RMSD). Therefore these blocks are realized by the circuits with measuring operational amplifier whose middle-time stability is about 2 % in the temperature range 10 – 30 °C. Systematic error operated by the dynamic range of A/D converters ADC 1,2 is neglectable. Dynamic range of ADC is possible to match with expected range of noise signal added to the video-signal by the change of amplification factor G and multiplication constant A in the microprocessor MPC. Resultant relative measuring error of developed instrument (verified by the final measurement) is less than 10 %.

4. CONCLUSION

Properties of this device was verified by the realization of the functional specimen and measurement. Low noise of the partial functional blocks (in the noise channel especially) is very important. This own noise must be compensated at the final calibration of this signal-to-noise ratio meter. It is completed development of the new software for the microprocessor MPC at present.

This device enables to find out the noise factor F of the arbitrary impedance matched transmission video-blocks or channels by means of measurement of input and output signal-to-noise ratio (Φ_{SNR1}, Φ_{SNR2}). Then it holds

$$F = (\Phi_{SNR1})^2.(\Phi_{SNR2})^{-2}. \quad (3)$$

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BIOGRAPHY

Václav Říčný was born in 1937. He is professor at the Department of Radioelectronics and vice-dean of the Faculty of Electrical Engineering and Communication Technology of Technical University in Brno. His research interests include TV technology and analog and digital processing of video-signals.