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MEASUREMENT OF THIRD HARMONIC FLUCTUATIONS FOR A PASSIVE COMPONENT UNDER LARGE PERIODIC BIAS

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Abstract: The noise (fluctuation) level and non-linear distortions can be established as a new criteria for selection of passive elements for different endurance (sustainability) and reliability groups. Measurement of third harmonic (TH) fluctuations and its implementation into the production testing system have been proposed. It can improve the process of quality estimation of high reliability elements.

Keywords: passive elements diagnostics, noise, fluctuations measurement.

1. INTRODUCTION

Quality and endurance tests are required according to the corresponding standards for high-quality resistors and capacitors. Such tests are carried out mainly using environmental trials having long duration and destructive character. Furthermore accelerated tests do not give the accurate evaluation of elements in normal operating conditions. A non-destructive and faster approach is needed for endurance estimation.

We propose to solve the problem by implementation into the production testing system additionally non-linearity and noise (third harmonic fluctuations) measurements. It has been proved experimentally that resistors and capacitors showing high non-linearity and low-frequency noise level are less stable and have shorter lifetime [1]. The proper choice of measured noise parameters (method and electrical circumstances of their measurement) and rules of classification into reliability group gives a possibility to predict reliability of tested elements individually [2].

2. NOISE AND TH FLUCTUATIONS

In passive elements there are thermal noise sources referred to losses and 1/*f* noise sources dependent on a technology of their production and circumstances of their operation. Increased level of non-linearity and 1/*f* noise in resistors and capacitors is mainly caused by instability of contacts, improper adhesion, electrodes and main element's material inhomogeneities and microcracks heterogeneity, weak contacts between a material and terminals, improper terminal construction (impulse, burst noise), slow processes of conducting (insulating) layer degradation or mechanical instability of an element, material aging.

1/*f* noise measurements require special instrumentation, appropriate conditions of element polarization and adequate time for averaging of measured noise waveforms. The current noise spectral density at the chosen frequencies divided by a square of the current is usually proposed as a quality indicator. It can be measured directly after a DC polarization of a tested component. However this procedure requires high DC voltage for device under test biasing and is time consuming. Only AC large-signal stimulation of the tested element without DC polarization can be used (Fig. 1) - in that case the $1/\Delta f$ noise (1/*f* noise amplitude modulated by a large-signal carrier), also proportional to the square of the AC current, can be measured in the frequency band near the carrier frequency. The frequency conversion of flicker noise to the upper sideband of the carrier frequency has a frequency and amplitude dependence. The modification of the measurement procedure relies on noise measurements in the low frequency band after filtration of AC stimulus signal. The level of the signal at the filter output is now much lower and requires very careful amplification in the low noise preamplifier but it does not contain the very strong AC stimulus signal. However, in that case there are heavy requirements on data acquisition system due to very high level of AC stimulation signal comparing to measured 1/*f* noise.

3. MEASUREMENT OF TH FLUCTUATIONS

A TH measurement is usually performed using available equipment [3] by the pure harmonic signal stimulation and a selective measurement of the TH. The main modules of such an instrument can be used to measure and analyse the voltage fluctuations on the load resistances $R_{Li}, i = 1, 2$ when the tested element Z_x is stimulated by a large periodic signal E_s (Fig. 2). It is specially useful instead of $1/\Delta f$ noise measurement when obtaining the appropriate resolution of noise power spectral density is extremely hard at large amplitudes of E_s. Due to noise and nonlinearities the electromotive forces of the harmonics E_{sh} and noise E_n are generated inside the element when the signal current is flowing through it. The harmonics of E_{sh} can be measured on the load R_{L1} and the third harmonic f_0 ($3f_s$) at the output of the selective filter. The correlation between the stimulus and response signals can be analysed by the measurement of the coherence function for the voltage fluctuations on the components Z_x, R_{L1} and R_{L2}. A residual inherent system nonlinearity should be no higher than –140 dB.

The results of voltage fluctuations on the load resistors R_{Li} were compared with the DC current noise measurements.

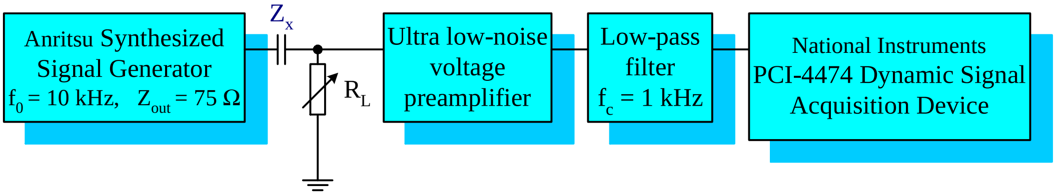

Fig. 1. Block diagram of the 1/f noise measurement without DC polarisation

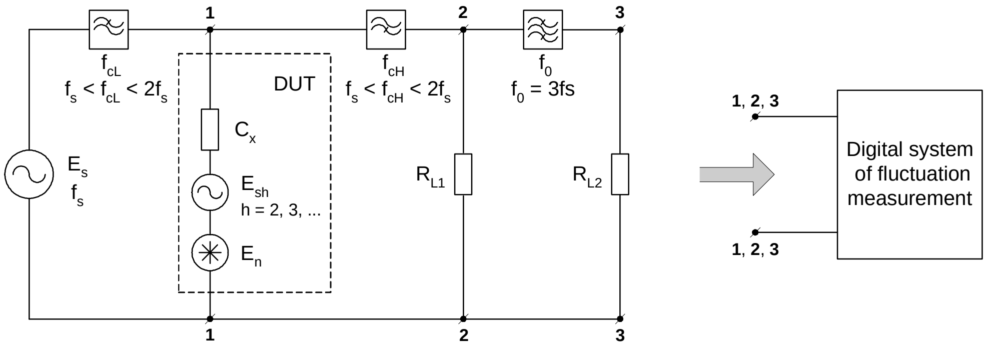

Fig. 2. The simplified diagram for complex TH and fluctuation measurements of Z_x

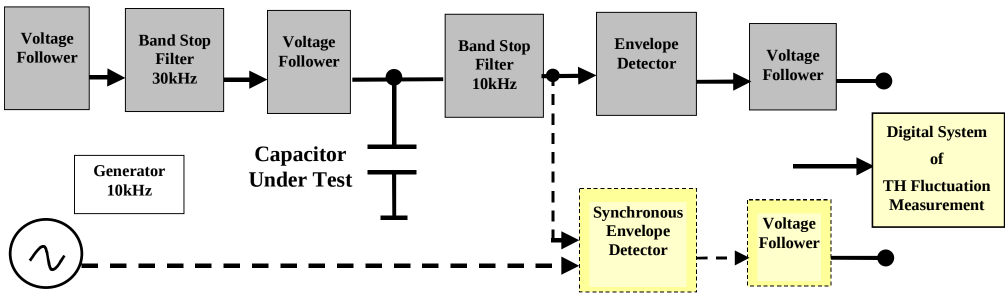

Fig. 3. Some modules of the system for TH fluctuations measurement

Selected experimental results of measurements in the system shown in the Fig. 3 for interference suppressor capacitors produced by MIFLEX (Poland) have been presented.

4. CONCLUSION

The implementation of techniques for nonlinearity and noise measurements in the system for production testing of high reliability passive elements [4] gives a possibility of individual testing of an every produced element for accepted criteria of classification.

The results suggest of using this method for other passive component testing when the direct noise measurements are relatively difficult to carried out. Adding the extra DC bias results in a cyclostationarity of resistor current noise which can be analysed by a cyclic autocorrelation function and power spectrum.

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