Evaluation of convection cooling conditions using Fourier and wavelet analysis in lock-in thermography

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1. Introduction

Heat dissipation is one of the major problems in modern electronic components. Therefore it is essential to provide proper cooling of such devices, often using forced convection due to its effectiveness. This paper describes thermal wave method in new application to evaluate convection cooling conditions of electronic devices. In the mentioned method authors investigated thermal response of the aluminum oxide board with heating resistor. Obtained thermal response was undergone Fourier and wavelet transforms. Given frequency spectrum was analyzed and the authors focused on the phase of thermal response. In addition Fourier and wavelet transforms comparison was performed. Results of the research were presented below.

2. Thermovision measurements

2.1 Measurement setup

A ceramic Al_2O_3 substrate with dimensions 50 x 50 mm and 0.8 mm thickness with centrally screen-printed 2 x 2mm^2 resistor has been used to perform research. This resistor was used as a heat source in our experiments. The ceramic substrate, not being painted or overglassed, provides high thermal resistance to the ambient, due to the low emissivity of the alumina in contrary to the high emissivity of the resistor's surface. Hence, temperature measurements could be easily carried out by focusing the thermographic camera on the resistor's surface.

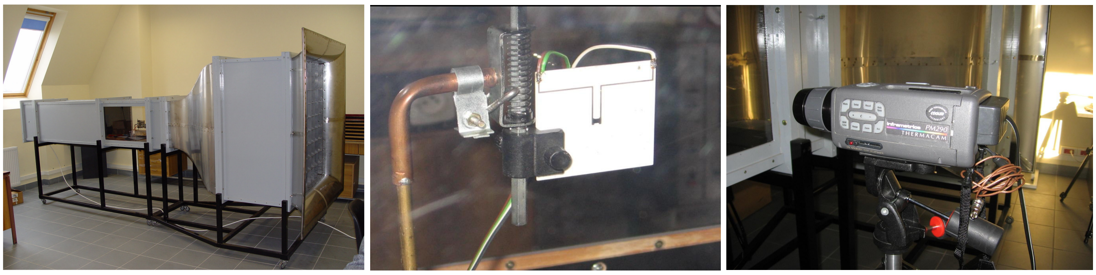

Fig. 1. Main elements of the measurement setup

Objects of investigations were placed in wind-tunnel, where with the aid of fan and power inverter, fluent and accurate airflow speed adjustment was possible. The energy was delivered to boards using pulse generator and simple transistor amplifier. The current flew through the resistor placed on aluminum oxide board. Thermal response of the circuit was measured by thermovision camera Inframetrics PM290, computer system for data acquisition and ThermalScope software Fig. 1**.**

2.2 Fast Fourier Transformation versus wavelet transform

In order to convert the time domain into frequency and to obtain the phase values FFT was performed. Because previous investigations proved that FFT method is proper tool for this application, authors tried to apply wavelet transform to check its usability in this field. Complex wavelets were considered, because phase evaluation is possible only from complex results, and continuous wavelet transform grants those only when complex wavelets are used. In particular, phase is calculated using four-quadrant inverse tangent (arctangent) of the each complex result. Results of the wavelet transform calculated with the complex Morlet wavelet are the closest to the FFT results, due to the sinusoidal shape of this wavelet. Hence for comparison of those, the complex Morlet wavelet is a good starting point.

2.3 Results and conclusions

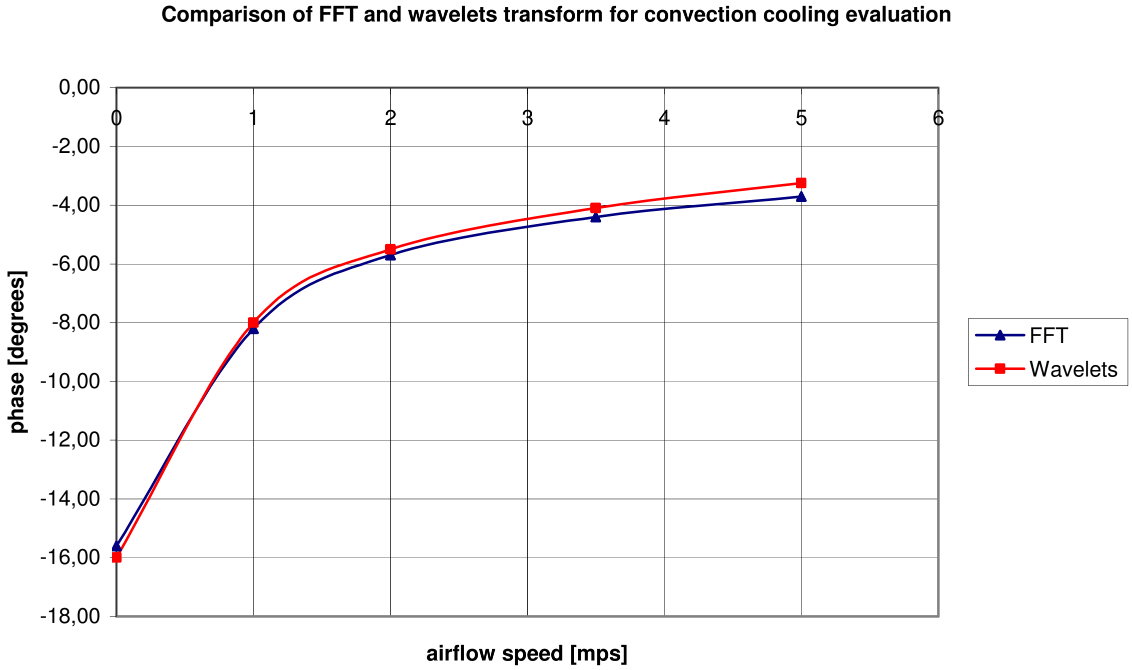

Fig.2. FFT and wavelet transform results

As shown in the fig.2, results obtained using both fast Fourier transformation and the wavelet transform are very similar. This proves that above methods are usable for evaluation of convection cooling conditions. Further research may also include involving other wavelets for analysis, such as Daubechies.

REFERENCES

[1] R. Olbrycht, B. Więcek, G. Gralewicz, T. Świątczak, G. Owczarek „Comparison of Fourier and wavelet analyses for defect detection in lock-in and pulse phase thermography", QIRT Journal, Vol. 4 – No 2–2007

[2] T.Świątczak, B.Więcek, K.Tomalczyk "Convective cooling evaluation of electronic devices using lock-in thermography", 14 th International Conference, MIXDES 2007, Ciechocinek, ISBN 83-922632-4-3 21-23 06 2007,

[3] T.Świątczak, B.Więcek, K.Tomalczyk "Characterisation of convection cooling for electronic circuits by frequency analysis", ICSES 2006 International Conference on Signals and Electronic Systems, Łódź, 17-20 09 2006

[4] R. Olbrycht, "Applications of thermal wave method for material properties investigation", M. Sc. Thesis, Institute of Electronics, Technical University of Lodz, 2007

[5] B. Staniszewski: "Wymiana ciepła" Państwowe Wydawnictwo Naukowe, Warszawa, 1979

[6] A. Teolis, "Computational signal processing with wavelets", Birkhauser, 1998