CONTACTLESS THERMAL CHARACTERIZATION METHOD OF SWITCHING MODE POWER SUPPLY

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This article presents results from the creation of switching mode power supply and non-contact thermal characterization of the separate elements that presents the risk of its reliability. Thermgraphics for several loads of different components are taken by infrared (IR) camera FLIR P640. The developed non-contact method is realized on the base of software engine for colour graphical analyzes of IR images optimized for parallel execution in grid environment. The method appliance leads to materially decreasing the time for development and implement due to the fats results and the non-contact diagnostics of heat-conducting in the researched electricity supplying device. Main appliance considered, when a primary thermal simulation is not conducted, but it is needed a real time thermal regulation and without building bundle of countless temperature sensors.

Keywords: Switching mode power supply, Infrared radiation, IR thermography

1. INTRODUCTION

The temperature graduation encountered in different electronic devices, like power supply devices (PSD), digital processors, high power amplifier, high power switches, etc., demands the application of careful temperature-aware design methodologies and the electro-thermal simulations of PCBs [1]. In most of the cases the results of different thermal simulations and modelling give good approximating results. It considers the coupled effects of the real surroundings of these cards and other dissipation elements in an operating system. However the simulation time may take hours, and different systems, different environment should be simulated again and again. The heat distribution and the places of high dispersion elements on an operating switching mode power supply PCB board can be measured and localized by using non-contact temperature measurement procedure.

In this article the suggested non-contact method for temperature measurements avoids the use of thermo-couples and temperature sensors in the tested power supply assembly [2]. The developed non-contact method is realized on the base of software engine for colour graphical analyzes of infrared (IR) images optimized for parallel execution in grid environment [3]. A FLIR IR camera type P640 640×480 pixels which detects the infrared radiation of the surface of the measured object in the range 7,5 ÷ 13 μm and from –40 ^{O}C up to +2000 ^{O}C was used. Using the Colour Transition Engine (CTE) a series of thermohistograms are generated for measuring the 3D

temperature deviation between two or more images. This approach allows effectively and continuously to process different critical objects in the power supply assembly without its proceedings to be suspended.

2. SWITCHING MODE POWER SUPPLY

An electricity supply device (ESD) construction is based on different used tools as MathCAD, CADStar and OrCAD. On Fig. 1 a part of the reverse transformer DC2DC' electrical circuit is shown. It is functioning in continues working rate, containing the elements researched with the suggested in this article approach. The transformer is realized as a planar with low profile ferrite core produced by Siemens (EPCOS).

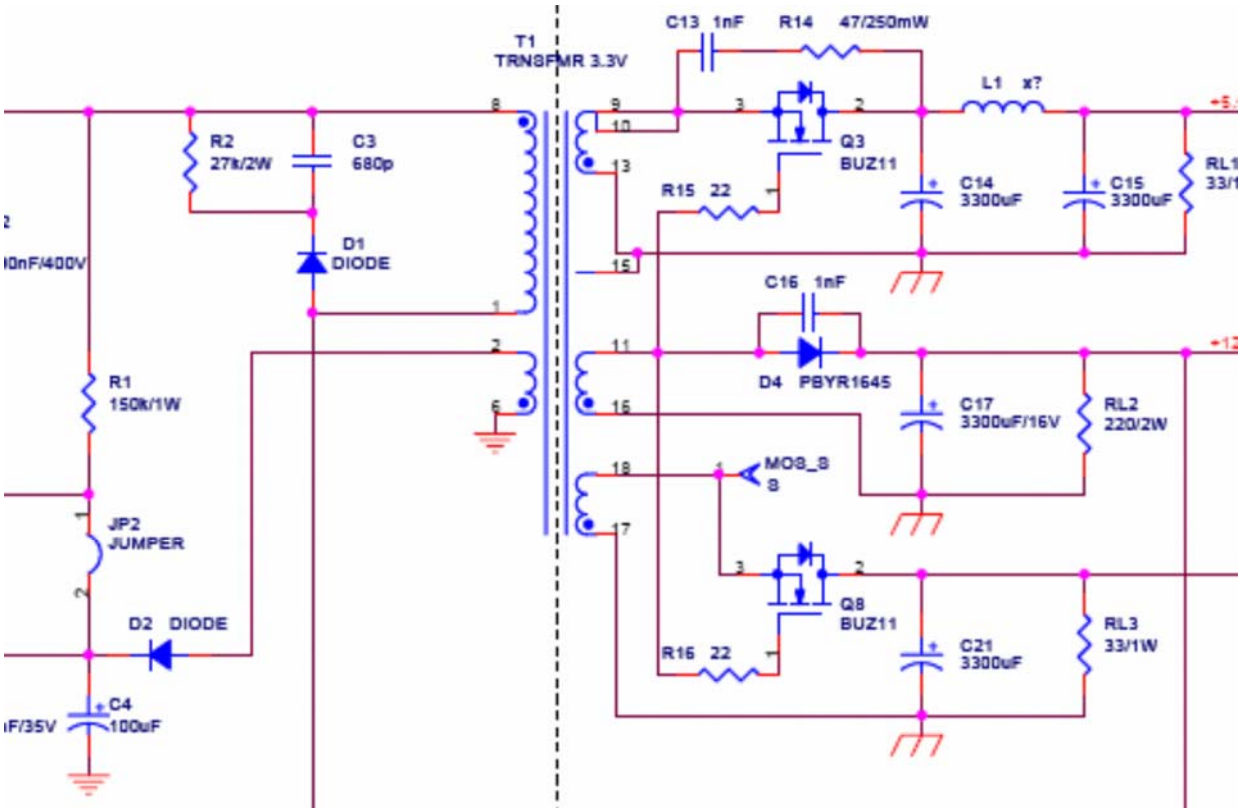


Fig. 1. Part of the electrical circuit, containing planar transformer T1, load resistor R1 and switch transistor Q3.

Voltage transformer is realized on one layer PCB in different variations. There is an implementation with SMD elements and PIC managing ATX control signals (Power Good, Power On) the coil for 3.3 V is integrated on the PCB

The specific realizations of this supply block (for voltages of: 2 V, 5 V, and 3.3 V) is in terminal work station (Fig. 2). The usage of: Planar impulse transformer, MOS power switch, Schottky diodes and/or MOS transistors for rectifier are contributing for high efficiency more then 85 %. The chosen circuit of electricity management that is capturing all 'unwanted' current changes through switch transistor is precondition for high reliability and fast processing of the 'error' in the outgoing voltages.

The processing speed of load changes form stand-by till full load from 75 W is

under 1 ms. The Power supply device (PSD) sustains to full "short" in the exit point as it drop out restores its working capability.

'Uninterrupted' (Continues-mode) working rate is precondition for low coefficient of the output currents ripple. For the tested mode of 5 V, the ripples are under 20 mV, but of 12 V are less than 50 mV. The compact design of the PCB and the selected low profile components are presenting the opportunity for easy implementation in various devices. Model of PSD feeds dispatcher realized with Mini-ITX mother board.

Fig. 2. Photo of the power supply unit.

3. APPROACH

In cases when termoelectrical simulation and modelling is not carried out, the implementation of thermographical measurements is leading to time saving for characterization of the heating distribution in real environmental circumstances and working rates.

For non-contact characterization and identification of the critical elements in the developed switching mode power supply it is used IR camera and specially developed software for IR image processing with 24-bit colour dept. The process speed is significant 500000 pixels are fully analyzed for 1 ÷ 5 s. The CTE controls the pollution levels by managing separately the colour channels for each pixel.

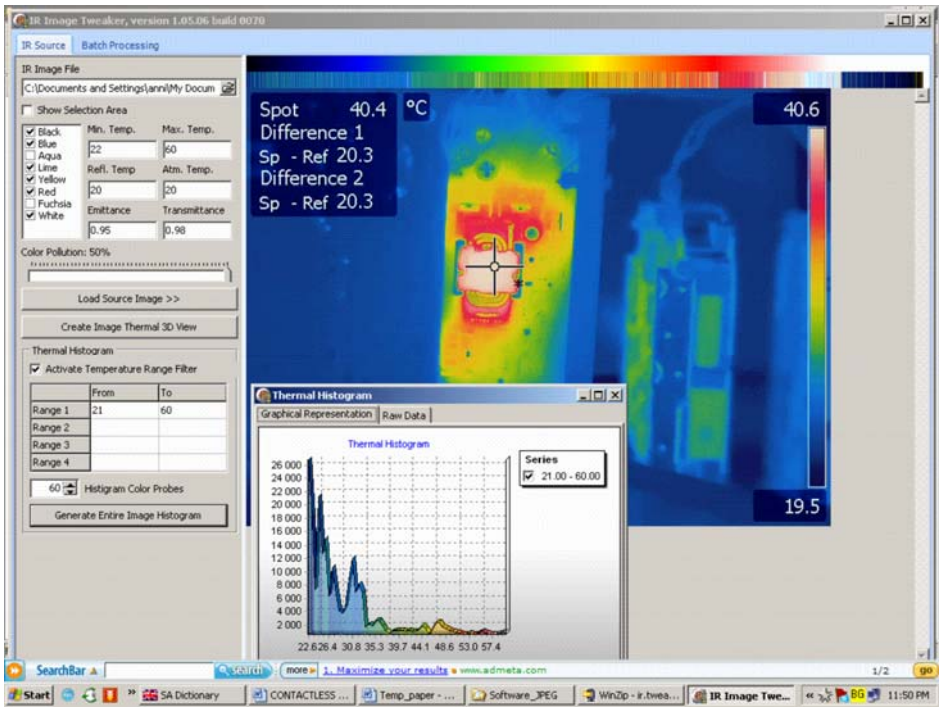


Fig. 3. Example thermal histogram for one temperature range of the plate of the

switching mode power supply.

Considerable problem in the quantity assessment of the surface temperatures of the electronic devices is the high integral density, as well as the used materials diversify (with quite different emissive capability, for example from 0.1 to 0.98) in its constructional integrity.

The developed approach is a comparison of image histograms of thermographics for one and the same object under different load stage. On Fig. 3 is shown thermal histogram of the printed plate of the power supply for temperature range of 22 ^{O}C and 60 ^{O}C.

The thermal histograms can be compared in four arbitrarily selected temperature ranges. In case of emissive capability batch processing of series of thermographics of one and same object is carried out under different working rates (respectively to different surface temperatures).

In accordance of the duration of transitions process, an individual snapshots can be generated after thermodynamic equilibrium is occurred, or automatically by setting interval of time between the individual snapshots with frequency up to 30 Hz. When the camera is controlled through computer, snapshots can be taken in time interval larger than 10 s.

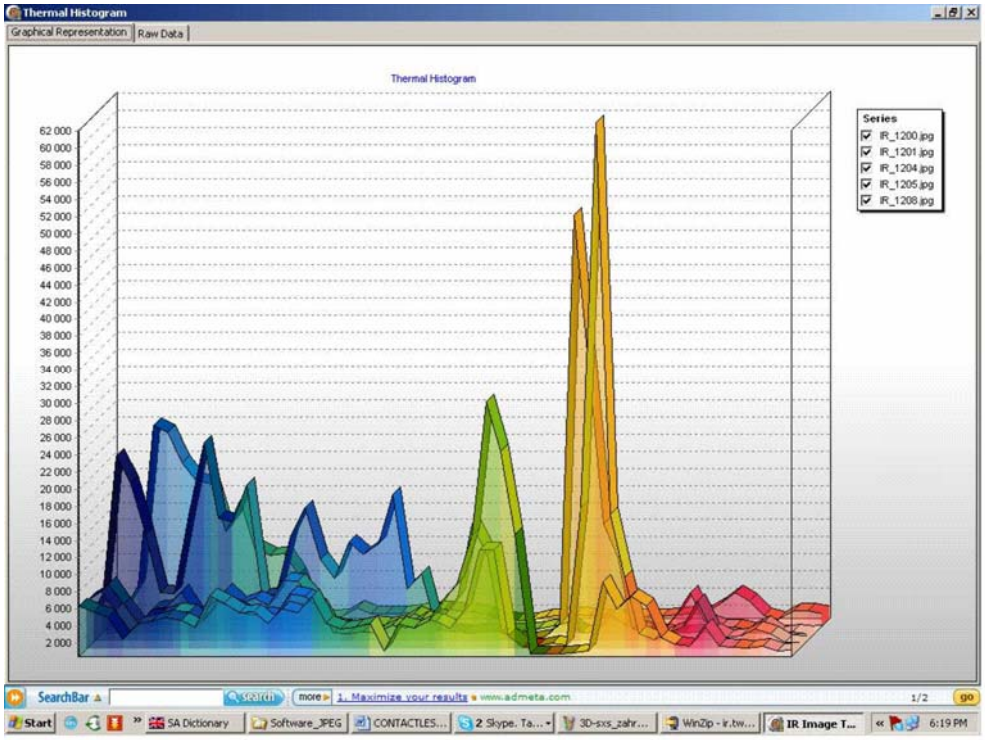


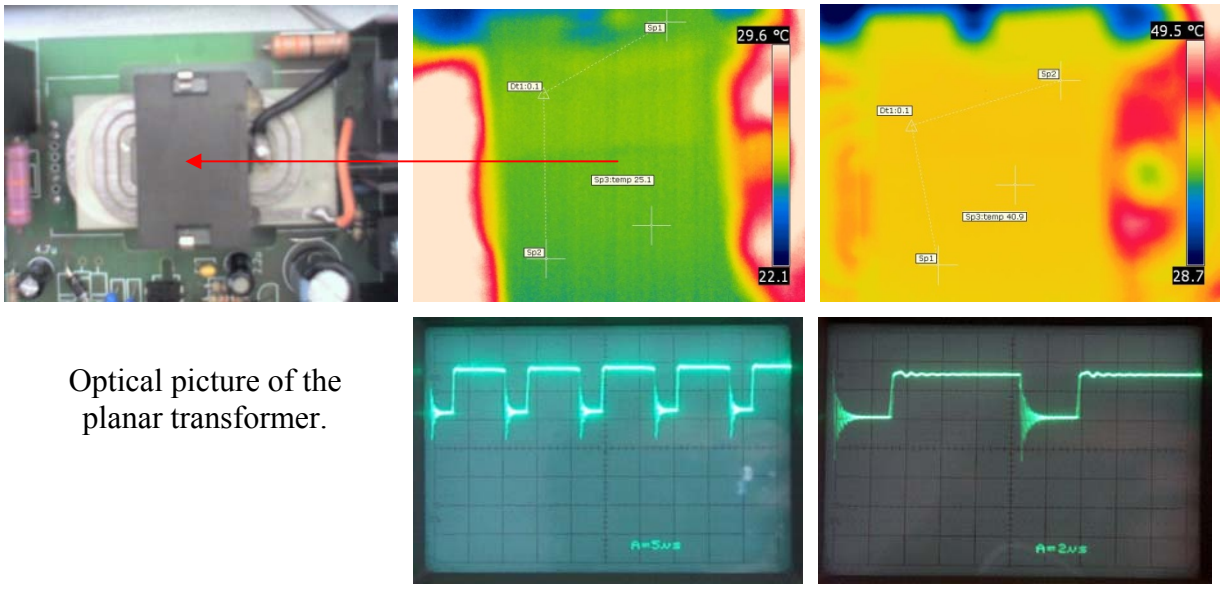
Fig. 4. Radiator histograms compared with switch transistor under loading of 60W.

On Fig. 4 it is displayed the batch processing result of the thermal histograms for the switch transistor with its radiator. The dip in the histograms can be recognized where the transistor is placed. The shifting of the peak sections is due to the process of conduction in the radiator.

Batch processing can be used successfully also for discovering of potentially unreliable components in power supply assembly. This is performed by comparing the temperature histograms with a template component.

4. RESULTS

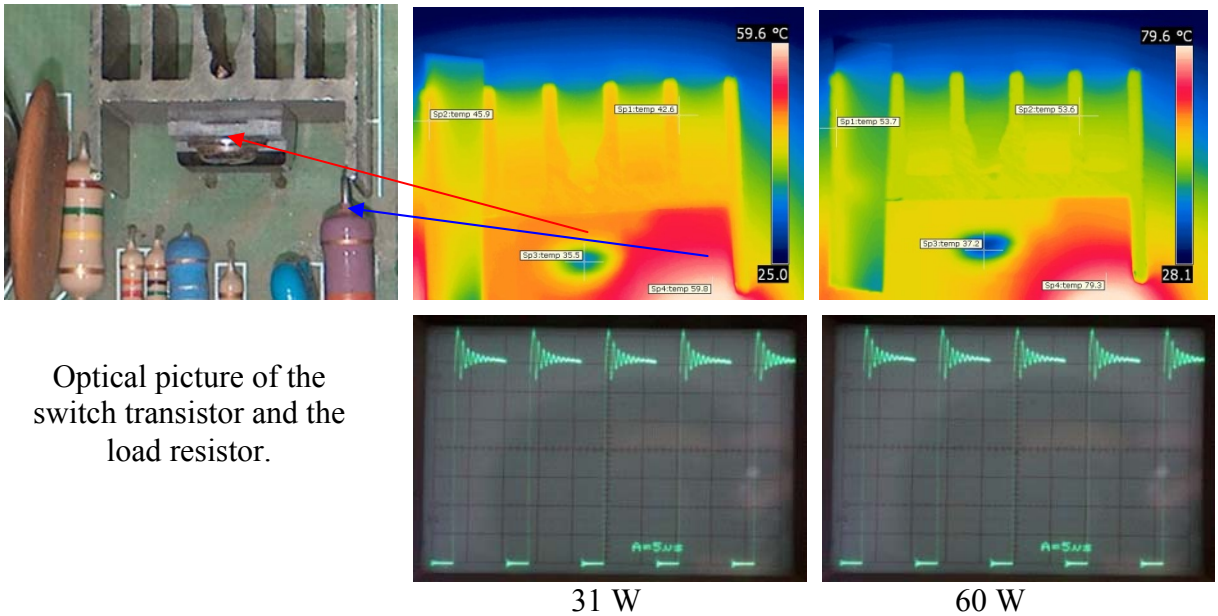
From the general thermal histogram it is seen surface heating of the switch transistor Q3 and load resistor R1. The planar transformer T1 was also studied. Indeed the temporary distribution on its surface is uniformly, as was measured temperature gradient not higher then 0.2 ^{O}C under different loads.



Optical picture of the planar transformer.

31 W 60 W

Fig. 5. Results for planar transformer.



Optical picture of the switch transistor and the load resistor.

31 W 60 W

Fig. 6. Results for the switch transistor.

Fig. 5 represents optical photography and T1 thermographics, as well as oscilograms of exit '5V' of the transformer prior to straighten up the load respectively of 31 W and 60 W. From the results it is seen that at 100 % load the temperature of the planar transformer is increasing with not more then 20 ^{O}C.

On Fig. 6 it is displayed analogical pictures for switch MOS transistor and part of the load resistor, as well as the oscilograms from the drain of the transistor. The surface temperature of the switch transistor under 100 % load doesn't exceed 70 ^{O}C,

and of the load resistor 80 ^{O}C.

On Fig. 7 it is shown three typical profiles for the thermographic of the switch transistor, from where the temperature grade can be read between the ribs of the radiator and the environment.

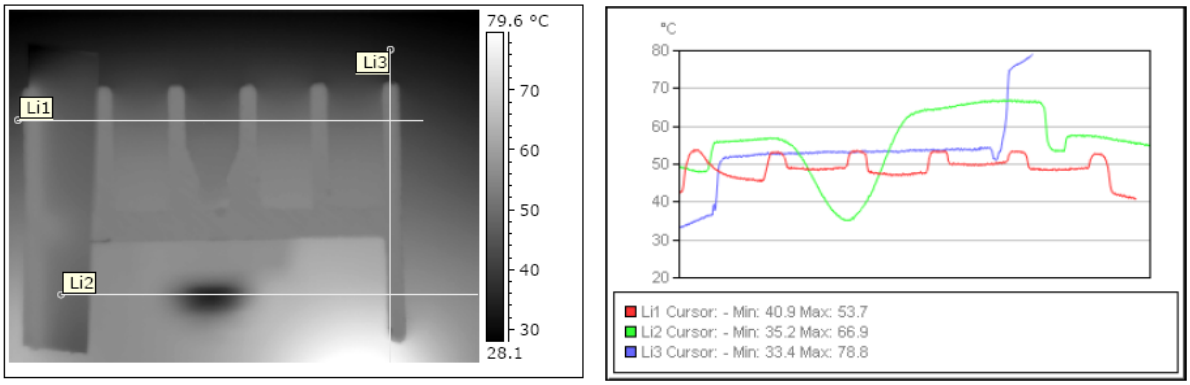


Fig. 7. Thermographic and IR profile on the marked curves

5. CONCLUSION

The suggested approach for non-contact thermo characterizing of impulse feed devices offers reliable, accurate and fast results for surface temperature distribution. The gathering and processing of experimental data is carried out without interrupting the work of the studied device. The relative precision of the assessments of the surface temperature, after processing of the thermograms, in comparison to the precision of the software of IR camera is up to 0.3 ^{O}C.

The suggested approach is applicable for every electronic device and it is independent of the chosen IR camera model. By this approach thermal images can be analyzed by two types of file formats: BMP and JPG-JPEG. The maximal detected temperatures are limited only by the capabilities of the type of the used IR camera.

The researches confirmed the expected low level of heat dispersing, which has allowed the PSD to operate without compulsion cooling (additional ventilation). In this case it is enough the normal air convection and the lack of moving mechanical parts is precondition for high reliability. The suggested approach leads to considerable decreasing of the time for development and implementation, due its fast results and non-contact diagnostics of the heat-lead in the Power supply device.

6. ACKNOWLEDGEMENT

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7. REFERENCES

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