Power electronic converters used in power supply systems are necessary for the correct operation of all electronic and electrical devices. Billions of such systems are manufactured worldwide every year. Due to such a large production volume, even the cheapest and smallest systems are highly optimized products. The most important optimization criteria are: production cost, geometric dimensions and efficiency. In connection with the above, it is expected to maximize the coefficient being the quotient of power and the product of volume and production cost.

One of the solutions to increase this coefficient, which has been growing in popularity in recent years, is the use of IMS (Insulated Metal Substrate) laminates. Thanks to the aluminum core of the plate, it is possible to dissipate heat from the converter elements more effectively than in the case of popular epoxy-glass laminates (FR4). This allows you to reduce the size of the cooling system, e.g. heat sinks and enlarged soldering pads, because the substrate itself takes over the role of the heat sink. Reducing the dimensions of the cooling system results in reducing the dimensions of the entire system and reducing the distance between the components of the converter.

The reduced distances between the components and the much higher thermal conductivity of the substrate with an aluminum core compared to FR4 result in an increase in the importance of mutual thermal couplings between the componetns. This significantly hinders the design of such systems because commonly used circuit simulation programs do not contain models that allow to take into account the influence of these couplings on the temperatures of individual components. For this reason, the results of converter temperature distribution calculations using these programs are typically significantly underestimated. On the other hand, performing reliable simulations using finite element simulation programs is very time-consuming, and due to the high complexity of the printed circuit board (PCB) design and the multitude of materials used, it is often impossible.

Therefore, in order to solve the problem of computer simulations of power electronic converters presented above with the use of popular simulation tools, the applicant plans to develop a method for quickly determining the temperature distribution in a power electronic converter assembled on an IMS substrate. This method will combine the advantages of both simulation tools mentioned above: it will allow to determine the temperature distribution of the converter, and at the same time, thanks to the use of lumped mathematical models based on the proprietary solution to the problem of heat conduction, the result will be obtained in a relatively short time.

In order to keep the developed method friendly to design engineers, it will be implemented in the popular PSpice program, and all parameters of the mathematical models used in it will be possible to determine on the basis of datasheet of components and the design of the PCB. Due to the fact that no additional measurements will be required, it will be possible to carry out simulations before purchasing any of the converter components. This will allow for more efficient and effective design of power electronic converters, especially in the thermal management.

The main result of the project will be a calculation method implemented in the SPICE program together with the proprietary compact thermal model, allowing for the determination of the temperature at key points of the board (junction temperature semiconductor devices, temperature of the inductor core and winding, internal temperature of the capacitors), for the determination of the parameters of which only datasheets and layout are necessary paths of the designed PCB. The developed simulation method together with the formulated thermal model will be experimentally verified in the converters constructed by the applicant.