# Calorimetric Thermal Voltage Converter


## Abstract

The thesis is concerned with Thermal Voltage Converter (TVC), which can be used as a primary voltage standard in frequency range from 1 MHz to 100 MHz. Actually, as the best TVC in terms of metrological parameters in this frequency range is considered the Calorimetric Thermal Voltage Converter (CTVC) designed and build at National Research Council in Canada (NRC). In comparison with other TVCs, the NRC CTVC has the most 'flat' frequency response characteristic of its AC-DC transfer difference. On the other hand, the NRC CTVC has some disadvantages: a huge DC reversal error, difficult to manufacture, handmade multijunction thermocouple and a coaxial waveguide requiring complex and expensive technology. Moreover, the mathematical model of the NRC CTVC is numerically unstable for certain values of input parameters such as geometrical dimensions and material constants.

The main goal of the thesis was to design a CTVC which could be characterized by significantly lower dc reversal error, sensitive multijunction thermocouple and waveguide with repeatable and simpler technology. The AC-DC transfer difference of the new CTVC should be better or at least comparable to the AC-DC transfer difference of the NRC CTVC. Moreover, its mathematical model must provide numerical stability.

The main part of the thesis contains analysis of the reason of the dc reversal error of the NRC CTVC and proposes a method of its reduction. According to this study a physical model of the CTVC with approximately seven times lower dc reversal error was manufactured. Next, the thesis contains research and description of a multijunction thick-film thermocouple sensor, deposited onto a polyamide substrate. The new optimized sensor is characterized by sensitivity as high as some of thin-film thermocouple sensors, but it is much easier to manufacture and less expensive.

The thesis presents also an improved mathematical model of the CTVC which is numerically stable in wide frequency range which was used to calculate the AC-DC transfer difference of the CTVC as well as estimating its uncertainty.

The calculated AC-DC transfer difference results were validated by comparison with a planar multijunction thermal converter calibrated at Physikalisch-Technische Bundesanstalt in Germany. The measurement results confirm the correctness of AC-DC transfer difference values obtained from the mathematical model. The developed physical model of the CTVC is characterized by transfer difference comparable to NRC CTVC and its uncertainty in range of frequency from 1 to 100 MHz predestinates this new converter to become a primary standard of AC voltage in frequency range from 1 MHz to 100 MHz.