

Improved methodology for power loss measurements in power electronic switches using digital oscilloscope and MATLAB

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I. INTRODUCTION

Efficiency is one of the main aspects that have to be addressed when designing power electronic converters. The efficiency of such devices is estimated as the level of losses that take place during the energy conversion. Therefore optimizing efficiency and reducing losses is a priority when designing power electronics converters. This brings the need to have a fast and accurate way of measuring and estimating the power losses, both as total resulting losses and as the separate components of the conduction and switching losses. This paper suggests a measuring methodology for power loss measurements in electronic switches that allows accurate and fast results, using a cost effective current probe, two channel digital oscilloscope and MATLAB.

II. SUGGESTED METHODOLOGY

A. Structure of the suggested methodology

Figure 1 presents the block diagram of the suggested measuring methodology. The D.U.T. is a Power MOSFET. As shown on the figure the current through the MOSFET – I_D is measured with a specialized passive current probe. The suggested probe is shown on figure 3. The voltage across the transistor is measured by a normal voltage probe. The information from the two probes connected respectfully to channel one and two of the oscilloscope is collected and then transferred as numerical data to a personal computer. This means that every digital oscilloscope with two channels and data transfer can be used in this application. The data transfer for the different digital oscilloscopes can be by USB cable, serial communication, flash memory, est. The numerical data from the oscilloscope is then loaded by a specially developed program in MATLAB. The MATLAB program output data can contain different information mathematically obtained using the acquired voltage and current: the total losses, the switching losses and the conduction losses of the D.U.T..

B. Advantages of the suggested methodology

The suggested methodology has several advantages that increase the acquisition speed and accuracy of the measurement:

- Using MATLAB for calculation and visualization of the output losses eliminates any error that can be introduced from incorrect reading of the oscilloscope's data.
- Acquisition speed of results from the measurement is increased, especially for multiple measurements.
- Improved accuracy of the obtained output data – because the mathematical processing of the results is done separately by the personal computer using MATLAB.
- The suggested methodology is cost effective and doesn't require expensive equipment.
- The obtained data from MATLAB simplifies any further processing.
- The suggested methodology can be also applied for measurement of power losses in magnetic components.

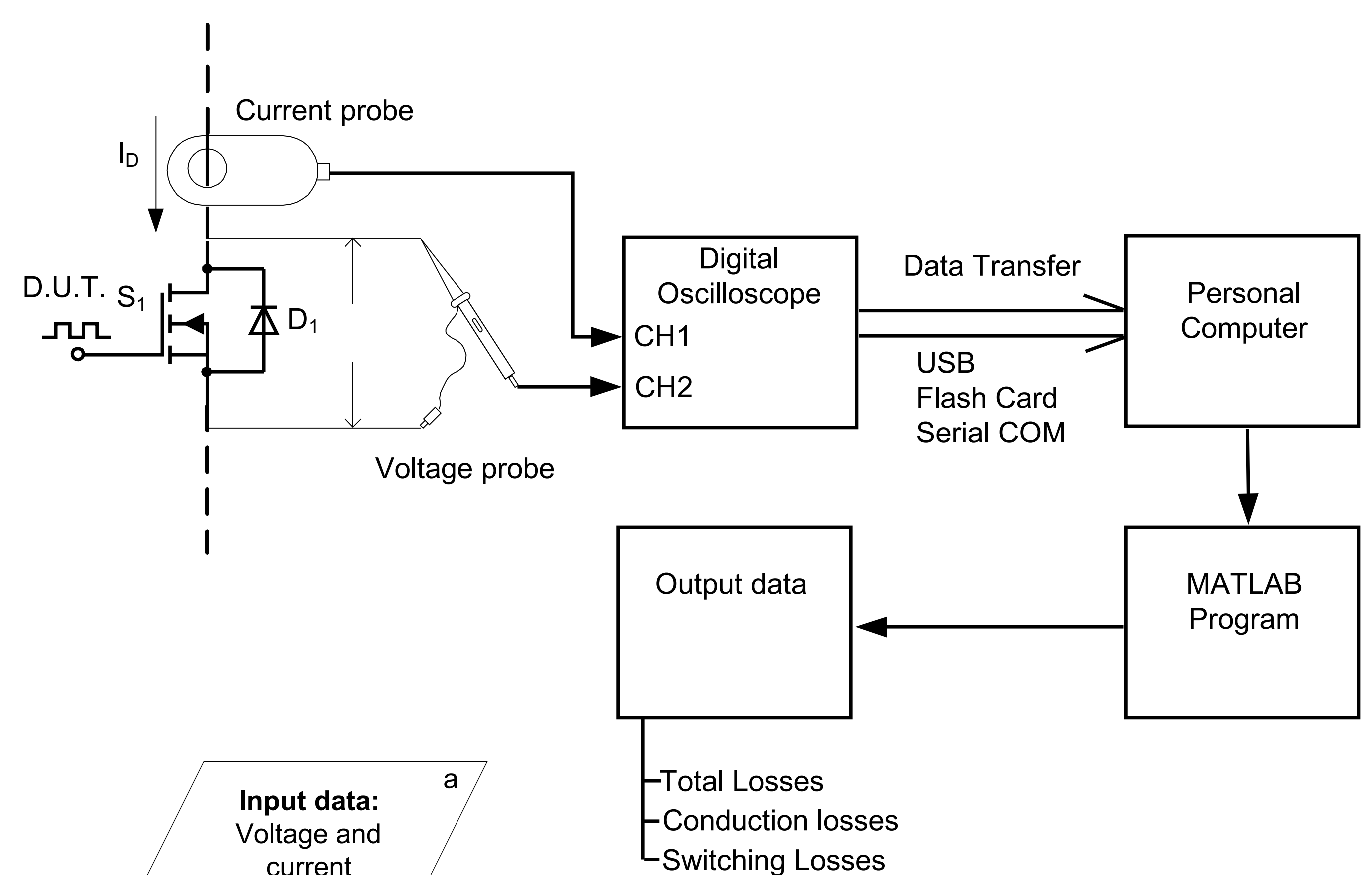


Fig. 1. Block diagram of the suggested algorithm

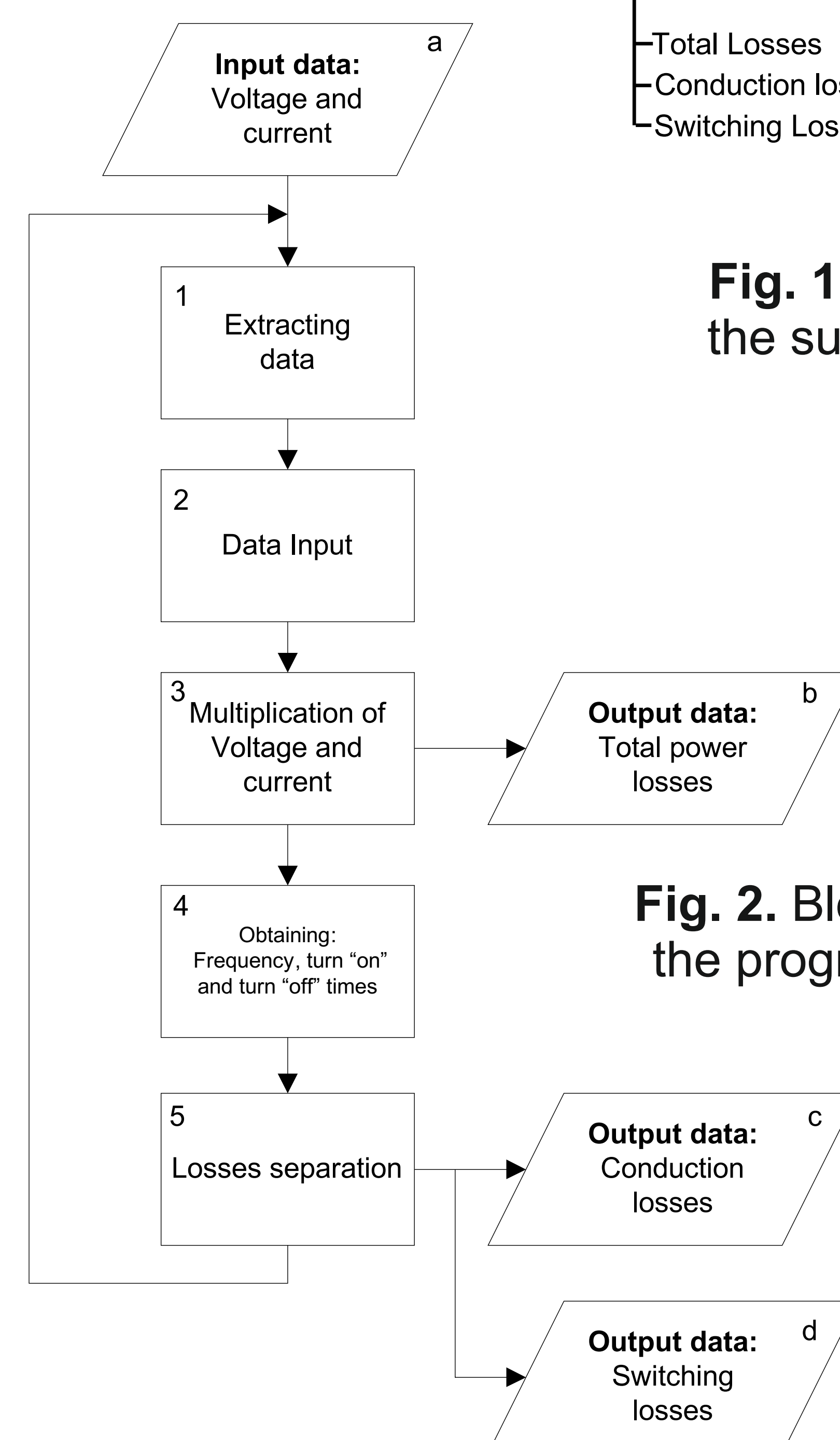
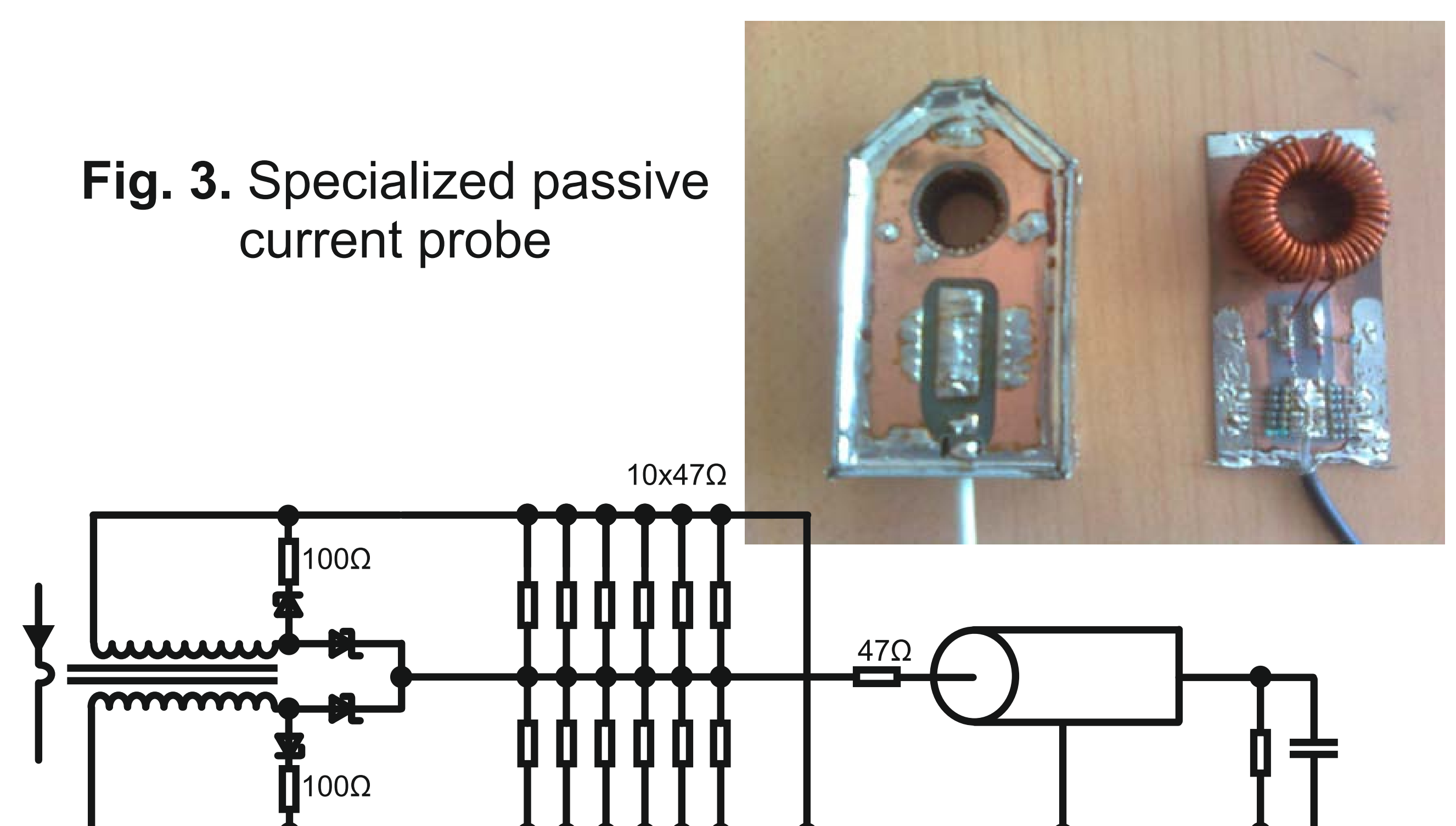


Fig. 2. Block diagram of the programs's source code

Fig. 3. Specialized passive current probe



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III. TEST RESULTS

The suggested methodology was tested with several power electronics switches – both MOSFETs and IGBTs.

The displayed results are from one of the tested MOSFETs. The main subject of the study was done in order to determine the accuracy of the suggested methodology compared to conventional power loss measurement using the oscilloscope's integrated multiplication function.

Table 1 shows a direct comparison between the multiplication of moment values of current and voltage – resulting in moment values of the power losses. As the table shows the difference between the data obtained via MATLAB calculation and the scope's integrated multiplication function varies highly depending on the count of numbers after the floating point. This is due to the already explained flaw in the multiplying algorithm of some oscilloscopes.

TABLE I. SAMPLE OF THE DATA MULTIPLICATION

time	voltage	current	Power calculated with MATLAB	Power obtained with the oscilloscope	error		Average power	
					absolute	relative	calculated	scope
μ s	V	A	W	W	W	%	W	W
- 3.12	16.2	0.496	8.0352	8	0.0352	0.44	0.721	0.621
-3.10	13.8	0.496	6.8448	6.8	0.0448	0.65		
-3.08	10.6	0.48	5.088	5	0.088	1.73		
-3.06	7.2	0.48	3.456	3.4	0.056	1.62		
-3.04	2	0.464	0.928	0.8	0.128	13.79		

Further the tests were done for different conditions concerning voltage, current and duty ratio. Figures 4 and 5 shows the difference between the MATLAB calculation and the scope calculation remains. It reaches a maximum of about 15%. Table II shows the results from the last accuracy tests and measurements presented in this paper. This test was done in order to compare the results of the suggested methodology – using MATLAB and the results done with the conventional oscilloscope multiplication to some basis (calibrated results). The selected basis is power loss measurement with calorimeter. Considering that the calorimeter is the comparison basis and that measurements were done for optimized measuring conditions (calibration, stable thermal environment, est.), the calorimeter's measurement can be viewed with error of 0%. The other two measurements in the table are done using the suggested methodology with two different oscilloscopes – TPS2014, specialized oscilloscope with multiplication function and PDS5022 – inexpensive oscilloscope with no multiplication function. The last measurement is done using only the TPS2014 and its integrated multiplication function.

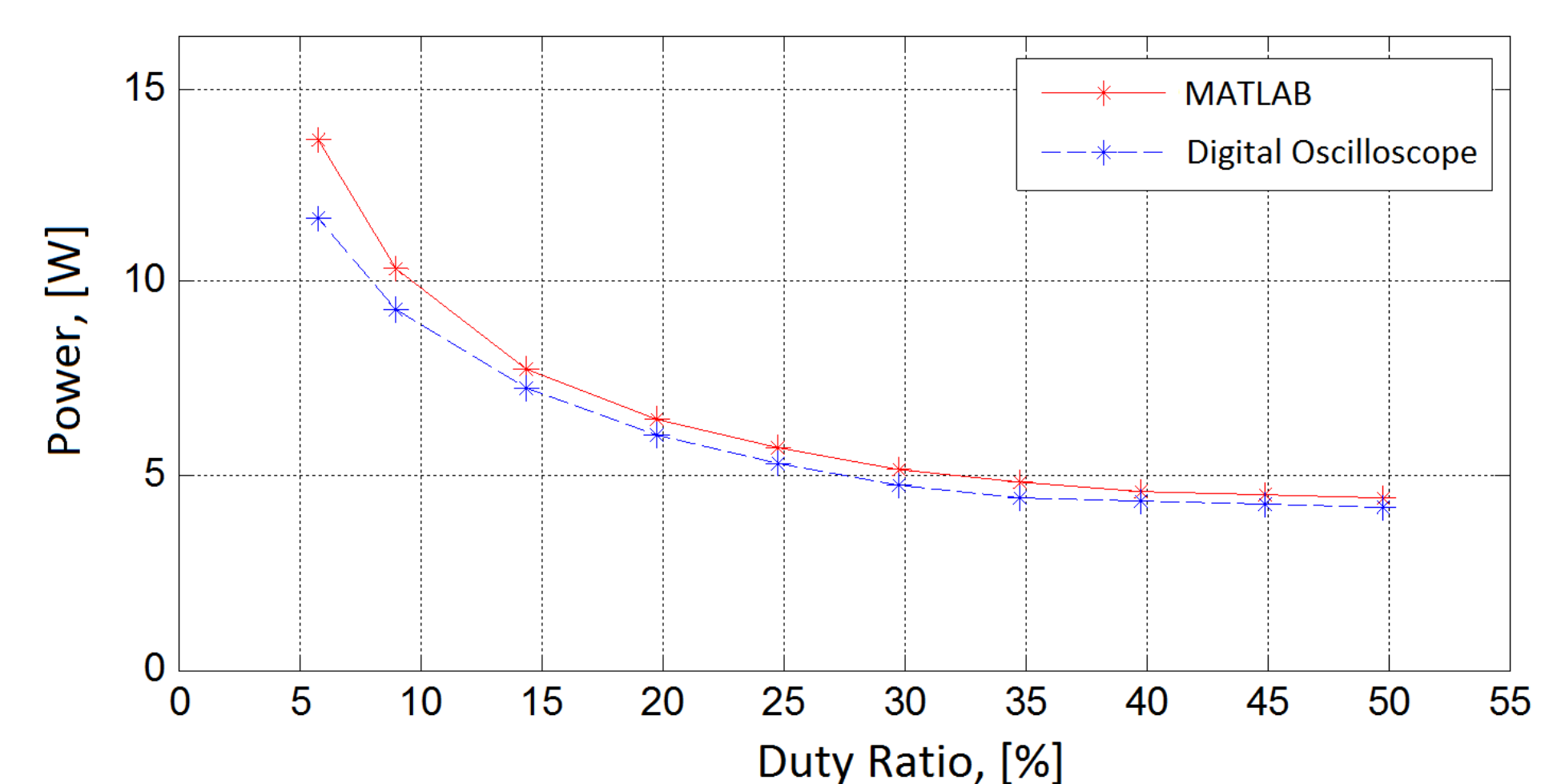


Fig. 4. Comparison between average power loss calculated with MATLAB and power calculated with digital oscilloscope

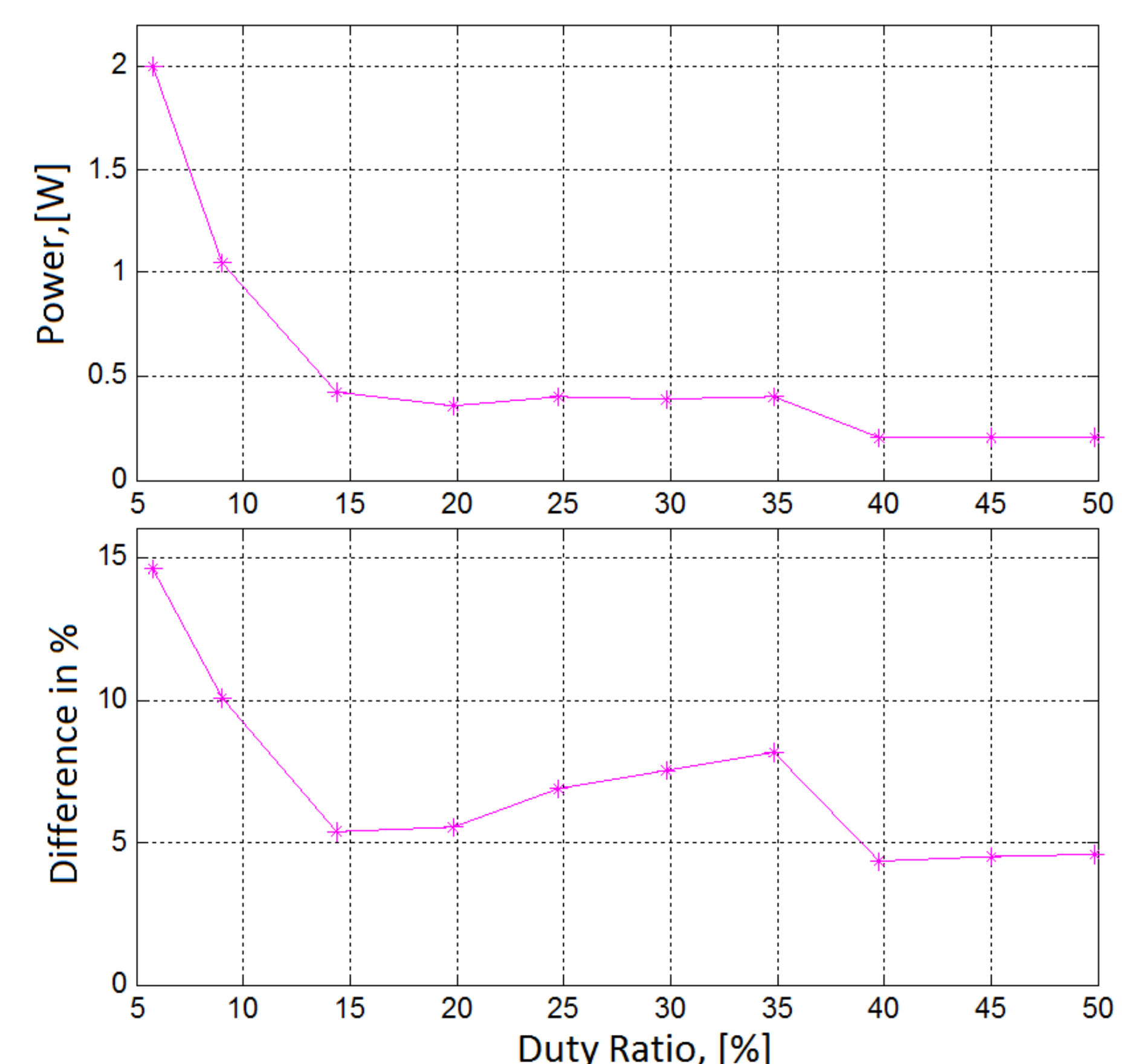


Fig. 5. Difference between power calculated with MATLAB and power calculated with digital oscilloscope.

TABLE II. COMPARISON OF DIFFERENT MEASURING TECHNIQUES

Type of measurement	Losses	Absolute Error	Relative Error
	W	W	%
<i>Calorimeter</i>	4.5	0	0.00%
<i>TPS2014 + MATLAB</i>	4.4099	-0.0901	-2.00%
<i>PDS5022 + MATLAB</i>	4.357	-0.143	-3.18%
<i>TPS2014</i>	4.1906	-0.3094	-6.88%

IV. CONCLUSION

An improved methodology for power loss measurements is presented and validated. The advantages of the methodology are fast, accurate and inexpensive power loss measurements. The proposed methodology is applicable for power switches and magnetic components loss measurements. Practical results and comparisons are presented proving the stated advantages.