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Thermal converter level dependence determination by digital sampling

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Abstract-This paper describes a method to evaluate the low frequency level dependence of Planar Multijuction Thermal Converter (PMJTC) based on digital sampling. The measurement system, the algorithms and the validation are also described. This method is also valid to obtain the absolute value of the ac-dc difference of a thermal converter at low frequency.

Key words: ac-dc difference, planar multijunction thermal converter, digital sampling, Level dependance

I. Introduction

There is not a SI definition for ac current and voltage, the reference is obtained by comparing their rms with the dc counterparts. The dc value is obtained by means of the Josephson effect. The majority of NIMs use thermal converters (1) to obtain this relation. The rms value is obtained by equaling the heat dissipated by Joule effect in a heater resistor applying ac and dc. Thermal Converters are limited to voltages from 0,5 V to 3 V and currents up to 10 mA. Due to different effects the response of the converters are not the same applying ac and dc. The characterization of the so called ac-dc difference constitutes the ac current and voltage reference. To obtain voltage up to 1000 V and currents up to 100 A the thermal converters are combined with range resistors for voltage and shunts for currents. Their values are obtained by means of a step-up procedure in which each range is compared with the lower. In this process it is assumed that there is not an ac-dc difference level dependence. However could be a level dependence on the range resistor, the shunt or the thermal converter. Planar Multijunction thermal converters (PMJTC) are widely used as thermal converter and they can experiment a level dependence at low frequency (2), (3).
This paper describes a fully automated measurement system to determinate the level dependence of the PMJTCs at low frequencies based on digital sampling. The system configuration, the measurement strategy, the algorithms (4), the software implementation and the validation method are also described. By means of this measurement system it is also possible to obtain the absolute vale of the ac-dc difference of a thermal converter at low frequency.

II. Measurement principle

The ac-dc transfer difference is defined by the following equation:

$$\delta \equiv \left. \frac{U_{ac} - U_{dc}}{U_{dc}} \right|_{E_{ac}=E_{dc}} \qquad [1]$$

Where U_{ac} is the input ac voltage, U_{dc} the average input dc voltages, E_{ac} the output voltage of the thermal converter when ac input voltage is applied and E_{dc} the output voltage with dc input voltage.

Figure 1 shows the configuration of the system to obtain the ac-difference of the thermal converter. By means of a Tee connector the same ac and dc voltage are simultaneously applied to the thermal converter and at the digital sampling system. Two voltage sources Fluke 5700 are used to apply ac and dc. A switch is used to alternate from ac and dc. The system is fully automated by controlling the sources, the switch, the digital multimeters readings and the sampling algorithms.

The digital sampling system is based on a high precision digital multimeter Agilent 3458. The output of the PMJTC for the applied ac and dc is measured using a digital multimeter.

The sampling system allows to determine the ac and dc applied values directly related to the dc Josephson. By these values and the corresponding PMJTC outputs the ac-dc difference is directly obtained by the definition. Finally the level dependence is obtained doing the measurement at different voltages

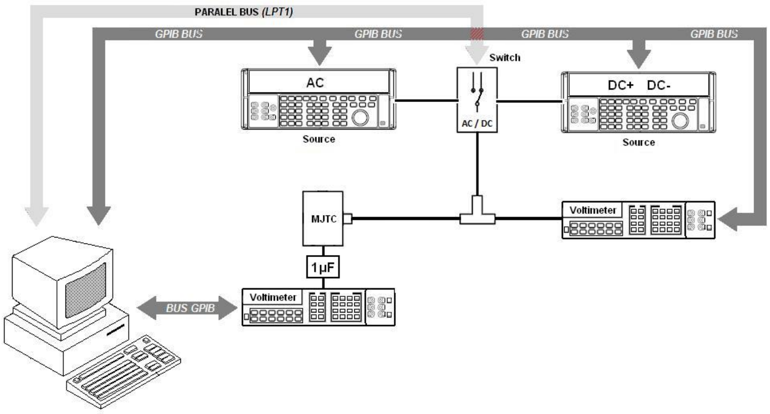

Figure 1: PMJTC Measurement system using Swerlein algorithm

The implementation of the system was made using LabView, thus allowing its complete automation. In a first step the Swerlein algorithm was implemented, allowing the configuration of all measurement parameters including the Measurement Time, the Aperture Target, the Minimal Harmonics and the Number of Bursts.
All the measurements were made with 30 seconds of measurement time, 0,001 seconds of aperture target, six harmonics and six bursts.

The main software allows the definition of the desired supply voltage, the ac voltage frequency, the repetitions number, the stabilization time between measurements and the measurement sequence.

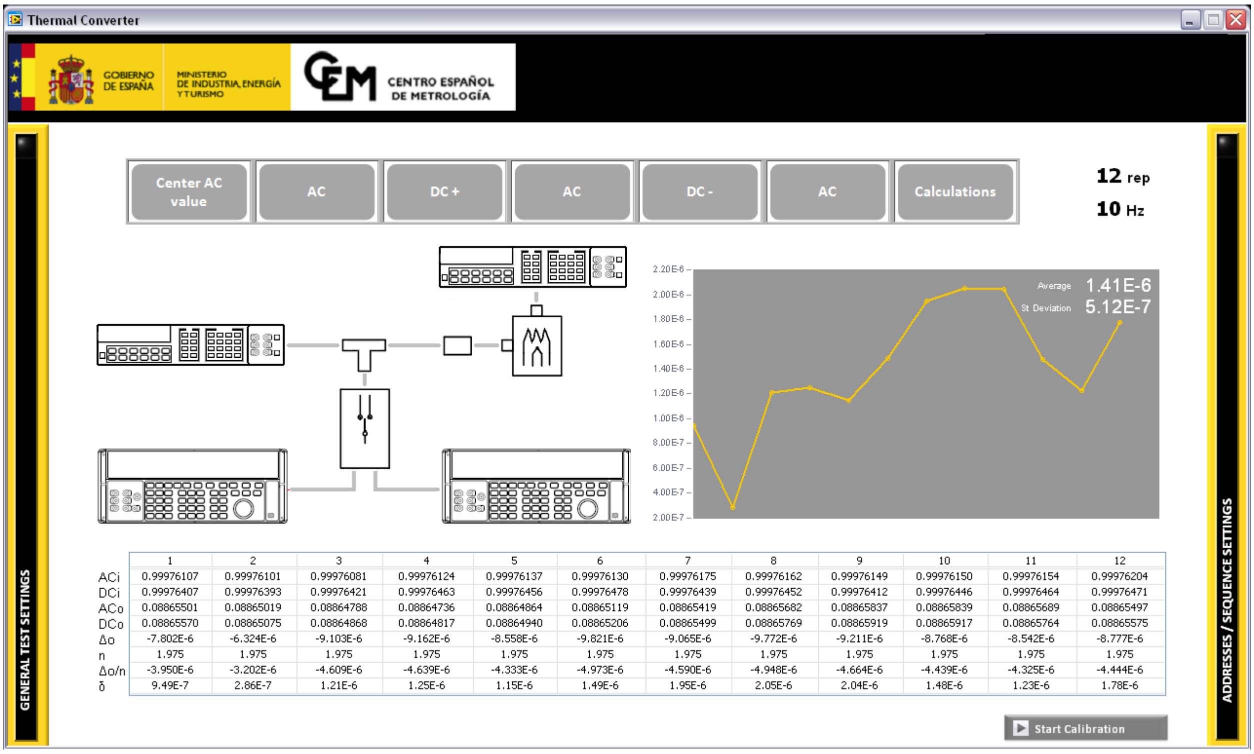

Figure 2: Front panel of the software used for the characterization of ac-dc transfer difference

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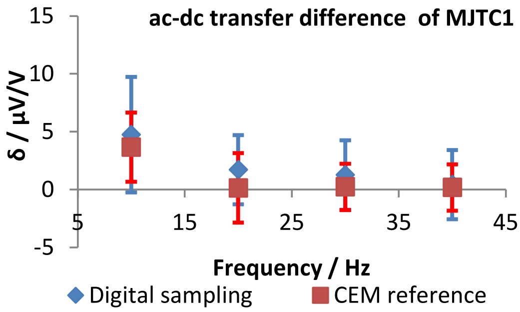
III. Preliminary Results

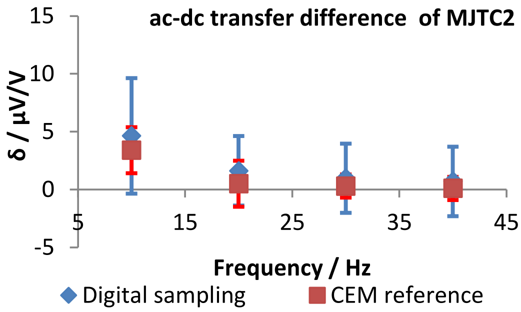
A measurement of the ac-dc transfer difference was made in two PMJTC at low frequencies and at 1 V. This was done to check the capacity of the measurement system to provide an absolute value.
Both PMJTC's where calibrated by CEM prior to this characterization.

		Frequencies at 1 V							
		10 Hz		20 Hz		30 Hz		40 Hz	
		PMJTC 1	PMJTC 2	PMJTC 1	PMJTC 2	PMJTC 1	PMJTC 2	PMJTC 1	PMJTC 2
Digital sampling	δ	4.74	4.64	1.72	1.62	1.26	0.98	0.43	0.71
	U	± 5	± 5	± 3	± 3	± 3	± 3	± 3	± 3
CEM reference	δ	3.66	3.4	0.14	0.5	0.23	0.3	0.18	0.1
	U	± 3	± 2	± 3	± 2	± 2	± 1	± 2	± 1

Table 1: ac-dc transfer difference of the two PMJTC at 1 V.
All values in µV/V and the uncertainty is for 95% confidence level

The agreement between both measurements can be analyzed by the graphs:



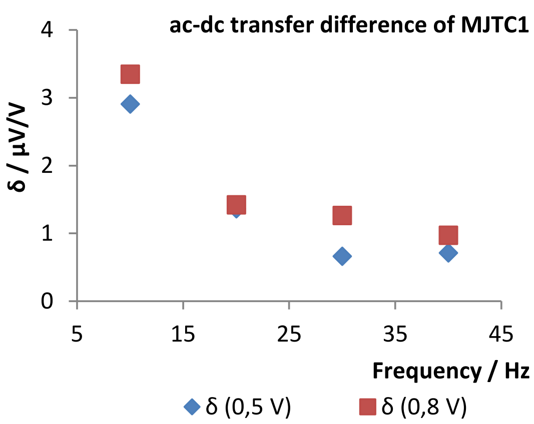


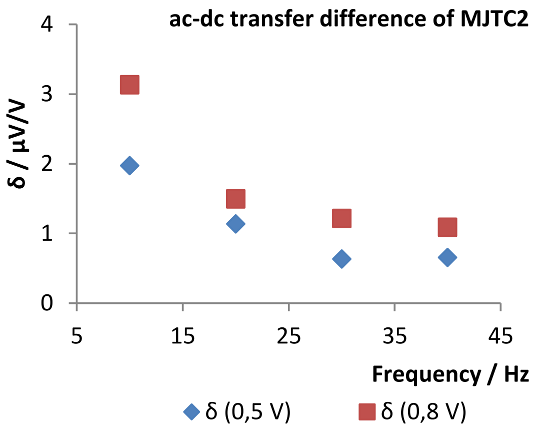
Both PMJTC's where measured at two different supply voltages (0,5 V and 0,8 V) to obtain their level dependence. To avoid the range shift from 1 V to 10 V and in order to obtain better precision the voltage coefficient has been evaluated from 0,5 V to 0,8 V.

The results are shown in table 2 and in graph 3 and graph 4.

	Frequencies							
	10 Hz		20 Hz		30 Hz		40 Hz	
	PMJTC 1	PMJTC 2	PMJTC 1	PMJTC 2	PMJTC 1	PMJTC 2	PMJTC 1	PMJTC 2
δ (0,5 V)	2.90	1.97	1.36	1.14	0.66	0.63	0.71	0.65
δ (0,8 V)	3.34	3.13	1.42	1.50	1.26	1.22	0.97	1.09

Table 2: ac-dc transfer difference of the two PMJTC at 0,5 V and 0,8 V supply voltage

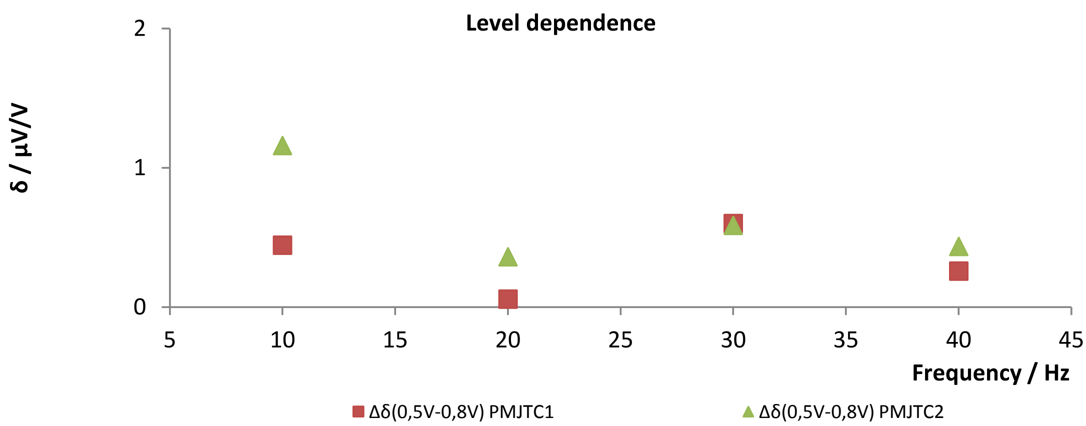




Calculating the differences between the ac-dc transfer:

	Frequencies							
	10 Hz		20 Hz		30 Hz		40 Hz	
	PMJTC 1	PMJTC 2	PMJTC 1	PMJTC 2	PMJTC 1	PMJTC 2	PMJTC 1	PMJTC 2
Δδ(0,5 V-0,8V)	0.44	1.16	0.06	0.36	0.60	0.59	0.26	0.44

Table 3: ac-dc transfer difference



IV. Conclusions

A method for determinate the level dependence of PMJTC using digital sampling has been described.
One of the PMJTC shows a level dependence particularly significant at 10 Hz coming to be half of the value found at the rated voltage.
Future measurements will be made to extend this study to several PMJTC at frequencies below 55 Hz and 1 V supply voltage.

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