AUTOMATION AND EVALUATION OF TWO DIFFERENT TECHNIQUES TO CALIBRATE PRECISION CALIBRATORS FOR LF VOLTAGE & CURRENT USING THERMAL DEVICES

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ABSTRACT

Low Frequency (LF) voltage and current are important parameters in Electrical Metrology. The standards for LF voltage and current are established by assigning AC-DC transfer difference to thermal devices i.e. thermal converter (TC) or thermal transfer standard (TTS) alongwith current shunts. Automated calibration systems have been developed using Null and Budovsky's techniques for calibration of precision calibrator for LF voltage and current using thermal devices (TC/TTS) alongwith current shunts. The technique based on the Algorithm developed by Dr. Ilya Budovsky (N.M.I. Australia) has been compared with the conventional null technique.

The softwares have been used to calibrate the calibrator in the entire LF voltage and current range using Holt converters and current shunts. Calibration results at 1V and 10V level in the frequency range from 10Hz to 1MHz are presented in this paper. The results show that the Budovsky's technique has reduced the complexity of AC-DC transfer measurements, measurement time and the uncertainty in measurement at some points.

INTRODUCTION

The established null technique and Budovsky's technique [1] for the calibration of precision AC calibrator using thermal devices have been compared. The measurement setup used in automated calibration is shown in fig. 1. The automation softwares [2] developed for these techniques can produce calibration report alongwith uncertainty budgets [3] at each current/voltage point of measurement. The platform used for its development is VEE Pro [4], a graphical user interface (GUI). The IEEE-488 interface has been used to control the instruments.

NULL TECHNIQUE

Firstly, nominal AC voltage is applied to TC and response in terms of emf output (e_{ac}) measured by the nanovoltmeter [5] is recorded. Then DC positive, DC negative voltage is applied to repeat emf output e_{ac} and corresponding voltages applied V_{dc} positive and V_{dc} negative are recorded and mean V_{dc} is calculated. Then absolute AC voltage (V_{ac}) is calculated using formula;

$$V_{ac} = V_{dc}(1+\delta_s) \qquad (1)$$

Where δ_s is the AC-DC transfer difference of the reference standard.

BUDOVSKY'S TECHNIQUE

As per algorithm AC-DC transfer difference assigned to unknown thermal converter is defined as delta (δ_x)

$$\delta_x = \frac{S_{ac}-S_{dc}}{n_s S_{dc}} - \frac{X_{ac}-X_{dc}}{n_x X_{dc}} + \delta_s \qquad (2)$$

Where S_{ac} and X_{ac} are the mean emf outputs of the standard TC and TC under calibration when AC is applied.

S_{dc} and X_{dc} are the mean emf outputs of the standard TC and TC under calibration when DC is applied.

n_s and n_x are the exponents of the standard TC and TC under calibration.

However in case of calibrator, term $(X_{ac} - X_{dc})/n_x X_{dc}$ of equation {2} becomes zero because $X_{ac} = X_{dc}$ so the formula to calculate AC-DC transfer difference (δ_x) assigned to calibrator reduces to;

$$\delta_x = \frac{S_{ac}-S_{dc}}{n_s S_{dc}} + \delta_s \qquad (3)$$

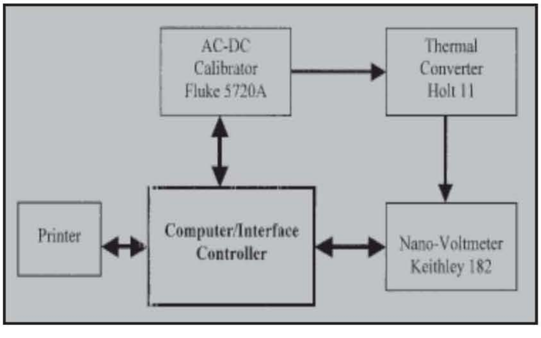


FIG. 1: CALIBRATION SETUP

Absolute AC voltage (V_{ac}) of calibrator is calculated using formula;

$$V_{ac} = V_{dc}(1+\delta_x) \qquad (4)$$

MEASUREMENT RESULTS

The results of calibration at 1V and 10V level using null technique and Budovsky's technique have been compared in table 1 & 2 respectively. Fig. 2 & 3 shows the comparison of uncertainty at 10V using both the techniques.

Table 1: Results at 1V

Frequency (Hz)	Null Technique		Budovsky Technique	
	V_{ac} (V)	Unc. (V)	V_{ac} (V)	Unc. (V)
10	0.999999	0.000013	1.000008	0.000010
20000	1.000004	0.000017	1.000010	0.000009
300000	0.999886	0.000018	0.999895	0.000011
500000	0.999757	0.000021	0.999744	0.000014
1000000	0.999749	0.000026	0.999760	0.000019

Table 2: Results at 10V

Frequency (Hz)	Null Technique		Budovsky Technique	
	V_{ac} (V)	Unc. (V)	V_{ac} (V)	Unc. (V)
10	9.999979	0.000232	10.000021	0.000116
20000	9.999981	0.000078	10.000026	0.000069
300000	9.998939	0.000112	9.998928	0.000104
500000	9.998264	0.000163	9.998287	0.000154
1000000	9.998192	0.000240	9.998143	0.000214

Fig. 2 - Type A Unc. of two Techniques at 10V

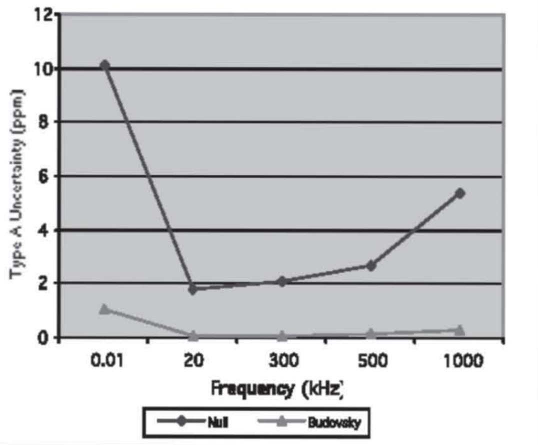
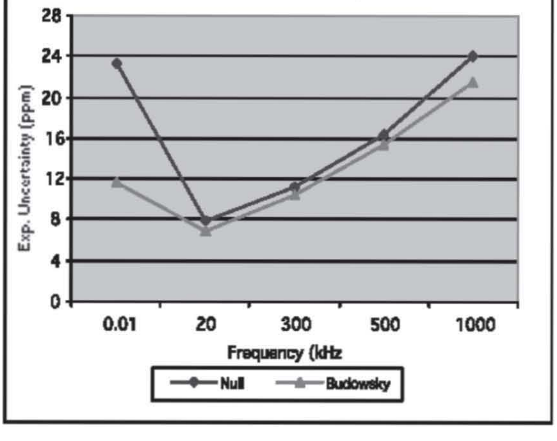


Fig. 3 - Exp. Unc. of two Techniques at 10V



CONCLUSION

The calibration results of precision AC calibrator using two different techniques have been evaluated. It has been observed that Budovsky technique has comparatively smaller type A uncertainty contribution as shown in fig. 2. Type B components of uncertainty are dominant therefore the impact of type A is not so visible in expanded uncertainty (fig. 3). As Null technique is time consuming and complex even in automation mode therefore Budovsky technique has made the AC-DC measurements easier and faster. It has also reduced the expanded uncertainties at few points. So the measurement technique based on Budovsky's algorithm is better than the Null technique.

The software prototyping in Vee Pro is faster in comparison to lower-level programming languages. The developed softwares automatically generate the calibration report and uncertainty budgets on each current/voltage point of measurement in the same excel file. These softwares save a lot of time and manpower, which is spent in manual measurements, preparation of calibration report and uncertainty budgets.

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