Two Wheels Instrument Station Tester (TWIST)

Calibration manual

DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

SUPREMAE DIGNITATIS IN 1343

1st December 2018

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Summary

1 Calibration process

According to ISO 5725-1, the measurement accuracy of an instrument means how much the measurement values depart from the real ones (the true). The accuracy of a set of measurement of the same entity can be decomposed in a systematic and a random component. As shown in Fig.1, the systematic component (Trueness) identifies the distance between the mean value of the set of measurement and the reference one, whereas the random component (Precision) represents the repeatability of the measurements.

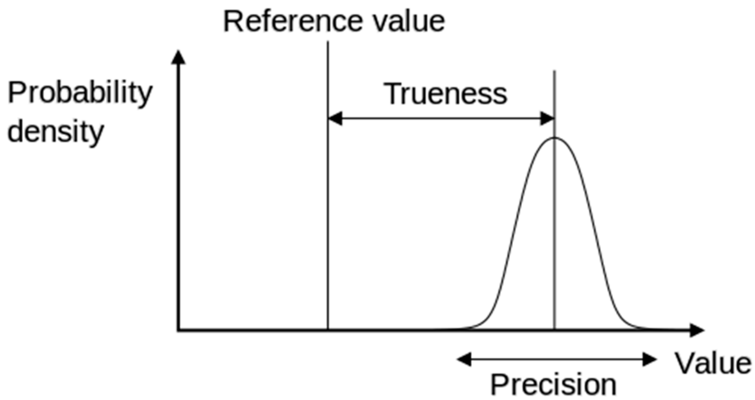

FIGURE 1ISO 5725-1 ACCURACY DEFINITION.

Generally, the voltage and current measurement accuracy of the instruments used in the Station Tester depends on factors like the temperature and environmental conditions. Therefore, a calibration procedure should be performed by the user. The calibration procedure aim is to correct the systematic errors on the voltage and current measurements acquired by the data-logger (DAQ Picolog ADC-24). Here, the materials and the procedures adopted to calibrate the instrument are described.

1.1 Materials

The calibration procedure of the Picolog-data logger is the same for both the voltage and current channels. The instrumentation set necessary to perform this procedure consists of:

1 high accuracy voltage (current) source properly calibrated or
2 high accuracy voltage (current) meter properly calibrated.

The measurement values picked from the voltage (current) meter [generated by the voltage (current) source] represent the true values. As this meter (source) is the reference instrument, its accuracy must be better than the accuracy of the devices used in the tester[1].

A non calibrated but stable voltage (current) source is sufficient if only a high accuracy meter is available.

[1] See: A.Carloni, F.Baronti, R. Di Rienzo, R.Roncella, R.Saletti, “Open and Flexible Li-ion cell station tester based on Python and Raspberry Pi”, Electronics journal 2018

1.2 Methods

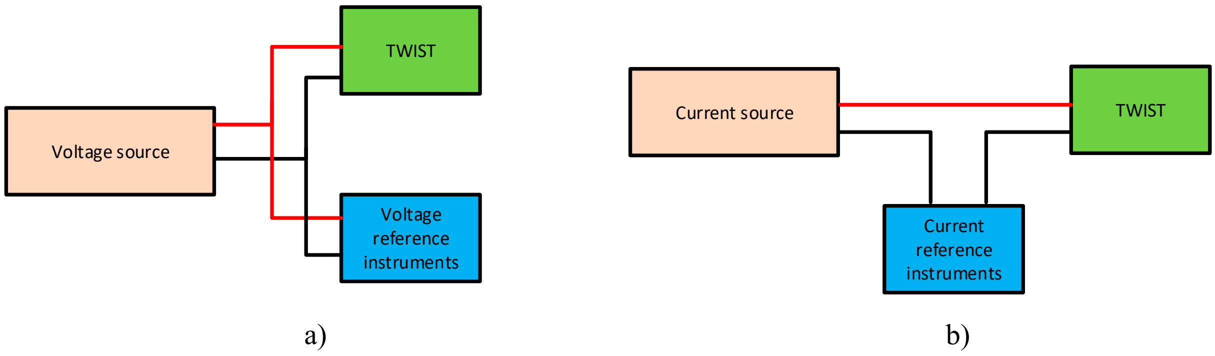

FIGURE 2 CALIBRATION INSTRUMENT CONNECTIONS: A) FOR VOLTAGE CALIBRATION. B) FOR CURRENT CALIBRATION

The procedure necessary to extract the voltage and current calibration parameters of TWIST can be performed as follow:

1. Connect the instruments as indicated in Figure 2. In the case of voltage calibration, the TWIST block represents the voltage channel of the PCB board connected to the Picolog data-logger. Instead, the TWIST block is composed by the high precision shunt sensor and the current channel in the PCB board connected to the Picolog data-logger, in the case of current calibration.
2. Set the source unit to a fixed voltage (current) value.
3. Set the sampling time of CST and voltage (current) reference instruments at 0.5 s.
4. Measure the fixed voltage (current) source point with both the reference instrument and the TWIST one, for ten minutes.
5. Repeat steps 2 to 4 for at least ten voltage (current) values, covering the entire input range of the TWIST instrument. The input voltage range is from 0 to 4.5V, and the input current range is from -50 A to 80 A.
6. Import the data acquired by both the reference and TWIST instruments on a data processing program package (for instance Matlab or Excel).
7. Extract the average values $X_{\mathrm{REF}i}$ and $X_{\mathrm{TWIST}i}$ for each voltage (current) measurement step, to reduce the effect of random component on the trueness measurement error.
8. For each measurement step, calculate the absolute error as follow:

$$E_{X\mathrm{i}} = X_{\mathrm{TWIST}i} - X_{\mathrm{REF}i}$$

where:

- X is V (for voltage calibration) or I (for current calibration)
- $E_{X\mathrm{i}}$ is the voltage (current) absolute error at i-th step.
- $X_{\mathrm{TWIST}i}$ is the voltage (current) mean value of data acquired by TWIST instrument at i-th step.

- $X_{\mathrm{REF}i}$ is the voltage (current) mean value of data acquired by reference instrument at i-th step.

9 Calculate the linear regression that best fits $E_X(X_{\mathrm{REF}})$ which is characterized by an offset Off_X and a Gain G_X, as follows:

$$E_X(X_{\mathrm{REF}}) = Off_X + G_X X_{\mathrm{REF}}$$

10 Finally, utilize the values of Off_X and G_X to calibrate the TWIST instrument. The following calibration equation is used to correct the measurement values

$$X_{CAL} = \frac{X_{Data} - Off_X}{1 + G_X} \qquad (4)$$

where:

- X is V (for voltage calibration) or I (for current calibration)
- X_{CAL} represents the value after calibration
- X_{Data} represents the measurements acquired by the data-logger[2]
- Off_X represents the offset value extracted from linear regression
- G_X represents the gain value extracted from linear regression

Fig.3 shows an example of Offset and Gain error extraction.[3]

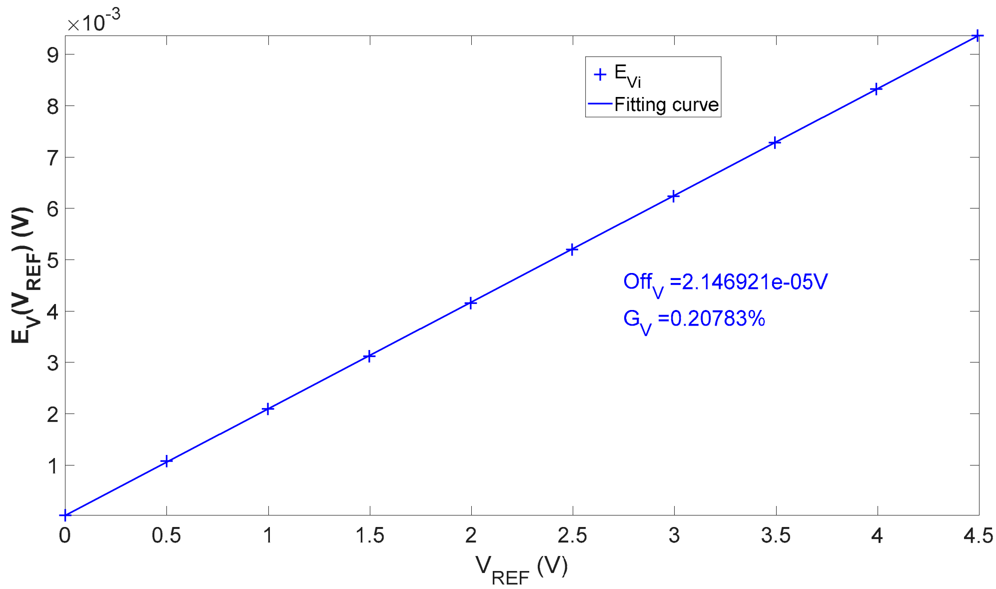

FIGURE 3 AN EXAMPLE OF VOLTAGE CALIBRATION TEST RESULTS.

[2] For data-logger conversion procedure see the User_manual.pdf
[3] See: A.Carloni, F.Baronti, R. Di Rienzo, R.Roncella, R.Saletti, "Open and Flexible Li-ion cell station tester based on Python and Raspberry Pi", Electronics journal 2018