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Internet Calibration for Electrical Metrology: First Application at IEN

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Abstract – *The paper deals with the use of Internet in the dissemination process of low-frequency electrical quantities to secondary calibration laboratories; feasibility studies on* Internet calibration, *performed at the Istituto Elettrotecnico Nazionale Galileo Ferraris (IEN), are presented.*

In particular, the experiments concern the automatic calibration of multifunction calibrators, by means of a travelling standard system (composed of a multifunction transfer standard and a laptop computer) using the Internet facilities with commercial or freeware software. The adopted solution doesn't require to the calibration laboratory any acquisition of hardware tools or the installation of dedicated software. The role of the secondary laboratory operator is limited to the realization of electrical connections before and during the calibration process.

Keywords – *standard, calibration, Internet, validation.*

I. INTRODUCTION

The Istituto Elettrotecnico Nazionale Galileo Ferraris (IEN), as primary metrological institution, performs dissemination of low-frequency electrical quantities to secondary calibration laboratories accredited by Servizio di Taratura in Italia (the Italian accreditation service), i.e. SIT Centres. Such activity is implemented by employing travelling standards, at present owned by SIT Centres themselves.

The use of Internet and its capabilities (real time transfer data, net meeting, etc.) allow a new method for dissemination also called *Internet calibration* or *e-calibration* [1-2], which could extend IEN dissemination services.

II. INTERNET CALIBRATION AT IEN

A. Traditional Traceability Transfer

The traditional method for dissemination of electrical quantities involves both individual standards (resistance and impedance standards, dc reference standards, etc.) and electronic instruments (digital multimeters, calibrators, etc.) [3] as travelling standards of calibration laboratories. The dissemination process can be manually-operated or automated, but always follows the following steps (see also Fig. 1, left):

a) pre-transport verification of the travelling standard: the calibration laboratory performs some measurements of it against the working standards;
b) transport of the travelling standard from calibration laboratory to IEN;
c) calibration of the travelling standard by IEN. The calibration process (depending on the particular standard), can include an initial verification, an adjustment and a final verification; it can be either manually-operated or automated;
d) return travel of the travelling standard from IEN to the calibration laboratory;
e) post-transport verification of the travelling standard, equivalent to step (a);
f) calibration of the working standards owned by the calibration laboratory by travelling standard, that become now a transfer standard, only if it pass post-transport verification and metrology confirmation [4].

The calibration laboratory is in charge of steps (a, e, f) and cannot benefit of its standards in the whole period (b, c, d), which include transportation delay and is typically of 30-45 days. During this period, the calibration laboratory is inoperative for all work that employs the standards involved in the process. This results in a heavy expense load for the calibration lab.

B. Internet-based traceability transfer

In the Internet calibration process, the roles of IEN and the calibration laboratory are reversed; IEN owns the travelling standards, and the transfer traceability process is (Fig. 1, right)

a') calibration of the travelling standard at IEN, with same methods of step (c);
b') pre-transport verification of the travelling standard at IEN, usually a fringe benefit of step (a');
c') transport of the IEN travelling standard to the calibration laboratory;
d') calibration of working standards of the calibration laboratory against the IEN travelling standard;
e') return travel of the travelling standard back to IEN;
f') post-transport verification of the travelling standard: IEN performs the same measurements of step (a') against the same working standards;

In this process the calibration laboratory performs the step (d') only, where the Internet facilities are heavily used; in fact the support of Internet in this process is necessary for the following reasons:

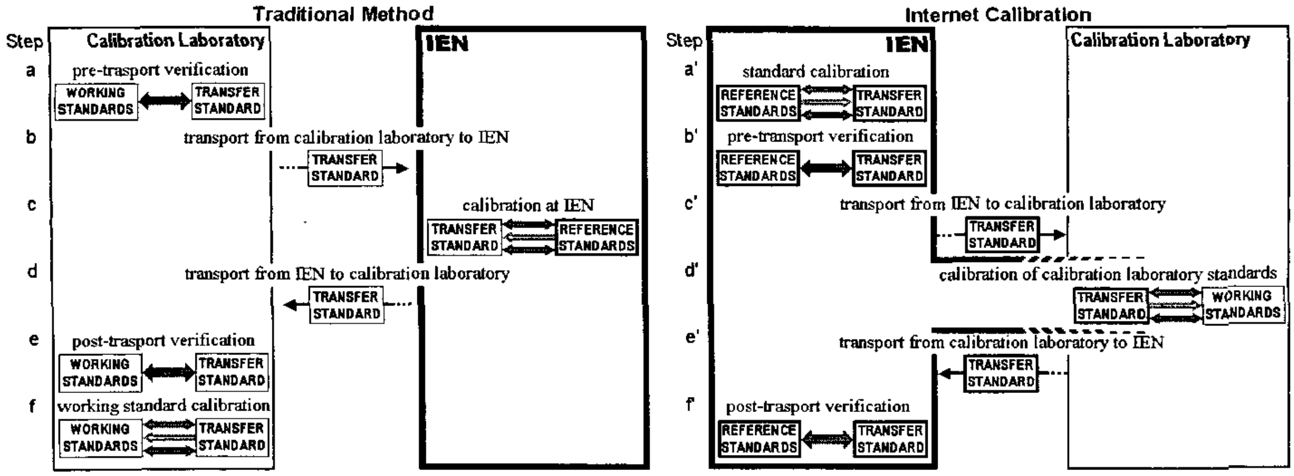

Fig.1 – Traceability transfer at IEN: traditional and via Internet

- the calibration laboratory operator is trained via net-meeting sessions to perform point (d'), which is not within his/her usual skills;
- if necessary, the pilot laboratory (i.e. IEN) can take over the management of the calibration process in real time, via remote control;
- for privacy of calibration data [5-6] the calibration results are encrypted and transferred to pilot laboratory immediately after calibration process;
- IEN can avoid frauds by checking auxiliary data (instrument serial number, previous calibration certificates, etc.)

The steps from (a') to (f') are obtained sending, along with the travel standards, a laptop computer where hardware and software components necessary to calibration process are installed. The proposed solution

- doesn't require to the Centre SIT the acquisition of tools for audio/video sessions, as instead appears necessary in the method adopted by USA's National Institutes of Standards and Technology [1,2];
- avoids downloading and installation, temporary or not, of programs and/or active components on a PC of the calibration laboratory, as is instead requested by UK's National Physical laboratory method [7-9] and Polytechnic of Turin method [10]. This point is of particular relevance if the PC is part of a accredited measuring system, since every change in hardware or software requires a revalidation of the system [5];
- avoids problems related with software portability;
- avoids the development of calibration programs specifically suited for calibration of remote instrumentation, or applications to translate instrument commands from Internet-protocol to local bus protocol (e.g., from Ethernet to GPIB), as instead necessary in remote calibration based on multi-agent technology proposed by Polytechnic of Milan and Polytechnic of Bucharest [11];
- since remote connection is necessary only for supervision or problem solving, connection session can be stopped and later resumed without damage to the calibration process, which can take several hours.

Other advantages of the method (a'-f') are:

- it's not necessary to transport standards belonging to the calibration laboratory, and normal activity of the same is stopped for a limited period (2-3 days);
- IEN technical personnel can supply assistance in real time in case of problems during the calibration process;
- if the travelling standard is damaged during the transport, the calibration laboratory isn't penalised in its usual activity;
- IEN can evaluate in an independent way the transportation effects on the travelling standard, whereas in (a-f) only an indirect verification of such effects is possible (e.g., by compatibility verifications against maintained standards).
- IEN can emit a calibration certificate in a short time (a certification in electronic form is also possible [12]);
- the Internet calibration can be part of the accreditation process of a calibration laboratory;
- the possibility of control during audits is strengthened.

III. RESULTS

A. The travelling standard system

Feasibility experiments of Internet calibration at IEN concerned the automatic calibration of multifunction calibrators, by employing a Wavetek 4950 Multifunction Transfer Standard (4950MTS) as travelling reference standard. In fact, the 4950MTS is designed as transportable transfer standard for dc and ac voltage, dc and ac current, resistance and frequency, to be employed as automated tool for calibrator calibration [8, 13].

The 4950MTS control software (v. 3.09, developed in the programming language WaveTest Program Generator v. 4.14 by Wavetek Ltd., UK) is loaded on the laptop (PCserver) that travels with the standard.

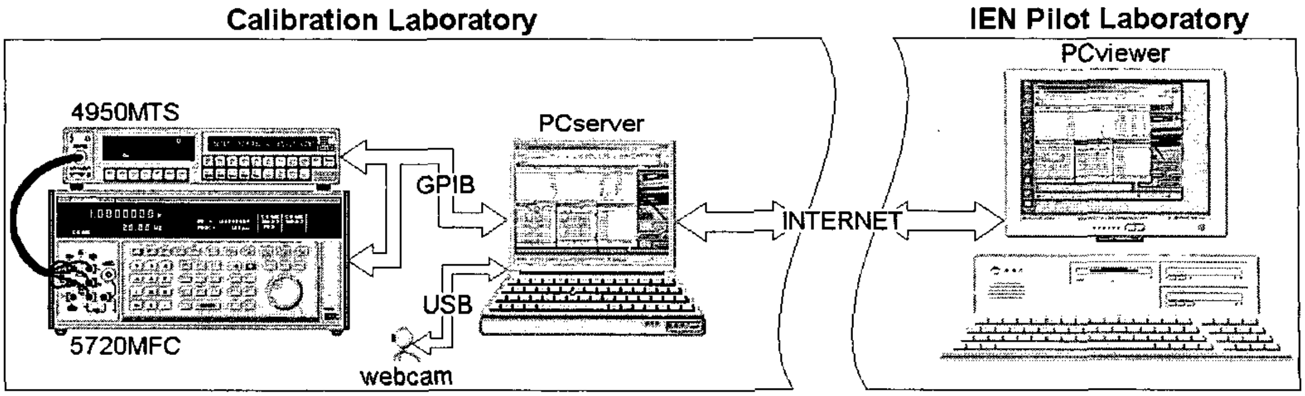

Fig.2 – Connection configuration for experiment of Internet calibration at SIT Centre no. 139

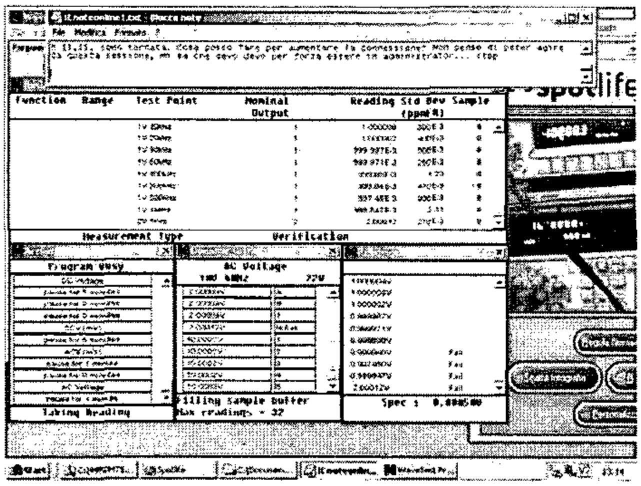

Fig.3 –PCserver desktop during the calibration at SIT Centre no. 139.

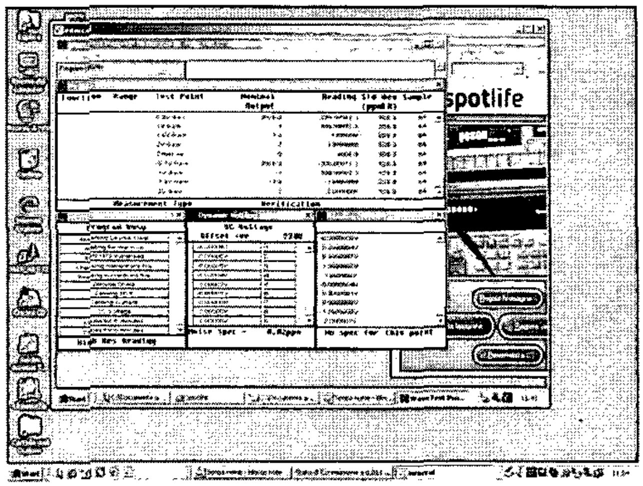

Fig.4 – PCviewer desktop at IEN with the interactive window of PCserver desktop .

This software is usually employed for the traditional dissemination; automatic calibration procedures cover more than 200 measurement points. The verification process can takes up to 6 hours and the adjustment process up to 4.5 hours, for a complete calibration (as described in sec. II).

The 4950MTS and the multifunction calibrator (MFC) under calibration are linked to PCserver via GPIB (a typical connection configuration is shown in Fig. 2).

A webcam for visual control and image recording of the ongoing calibration process is connected to PCserver via USB interface. Although instruments for environmental monitoring can be added, in the present case the environment data recorded by existing monitoring system of the (SIT accredited) calibration laboratory are trusted.

PCviewer connects to a PC of the IEN pilot laboratory (PCviewer) via Internet, using the TCP/IP protocol.

On both PCserver and PCviewer the WinVNC (VNC) software [14] is also loaded. VNC allows the real time monitoring of calibration activity, and has a client (PCviewer) – server (PCserver) structure. With VNC, PCviewer at IEN pilot laboratory shows a continuously refreshed interactive window with the entire content of PCserver screen (like in Fig. 3 and 4). VNC permits also driving PCserver with PCviewer mouse and keyboard, thus permitting to take over remotely the calibration process.

VNC login procedure is username and password protected; further protection level are ensured by settings of the operating system employed on PCserver (Windows 2000 Professional).

Data file transfer between PCserver and PCviewer is performed by common techniques of data interchange (ftp or http protocols, local Windows network).

B. The experiments

A first experiment was implemented within IEN local area network. The existence of a calibration laboratory was simulated, and the calibration of a Datron 4808 multifunction calibrator (4808MFC) was performed (the configuration was similar as showed in Fig. 2: 4808MFC was in place of 5720MFC), using the automatic procedure of WaveTest 4X0X_CAL program.

During the experiment, both fast connections (100Mbps LAN) and telephone modem communication links at 56 kbps were tested.

A second experiment, similar in its structure to the first one, was performed between IEN pilot laboratory and the calibration laboratory of Politecnico di Torino (SIT Centre no. 139). The 4950MTS and PCserver were sent for the calibration of a Fluke 5720A multifunction calibrator (the 5720MFC of Fig. 2). Since the 5720MFC adjustment is performed against three artefact standards (10 Vdc, 1 Ω and 10 kΩ, owned by the SIT Centre), the 4950MTS executed only verification measurements, using the automatic procedure of WaveTest 5700_CAL program.

The communication with IEN was via telephone modem at 28.8 kbps.

During calibration, several connection session from PCviewer to PCserver have been established and closed, verifying the ongoing of the calibration process, taking over PCserver control and acquiring snapshots of instrumental connections with the webcam, and exchanging messages. This last action is simply performed by a notepad window (Fig. 3, top); a chat program can be used instead. At the end of measurement process, PCviewer connected once time again to download the recorded images and measurement data.

IV. CONCLUSION

The experiments of Sec. III demonstrate that the Internet calibration method described in Par. IIB, implemented with techniques given in Par. IIIB, is practically feasible with a sufficient degree of control of the whole calibration process from IEN.

Next developments will be the validation of Internet calibration process, by comparison with the traditional traceability transfer process, where data from audits of both methods can be compared to evaluate their compatibility. Results of this validation will be presented at the Conference.

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