Closing the Measurement Gap.
An alternative to traditional methods for disseminating traceability in electrical calibration.

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Abstract:

Many labs employ single value artifacts to import their high level traceability, typically those labs without access to their own intrinsic standards (such as Josephson Arrays and Quantum Hall systems) but still requiring traceability at the lower uncertainty levels directly from National or higher echelon laboratories. A multifunction transfer device, originally intended for precision multifunction calibrator support, is also capable of providing traceability at low uncertainty levels for a number of parameters and values simultaneously as an alternative method of traceability import for traditional standards maintained within these laboratories. Control, automation and monitoring of the measurement process is possible via the internet from the higher echelon laboratory. This paper explores this application, discussing the technical, logistics, and economic issues involved.

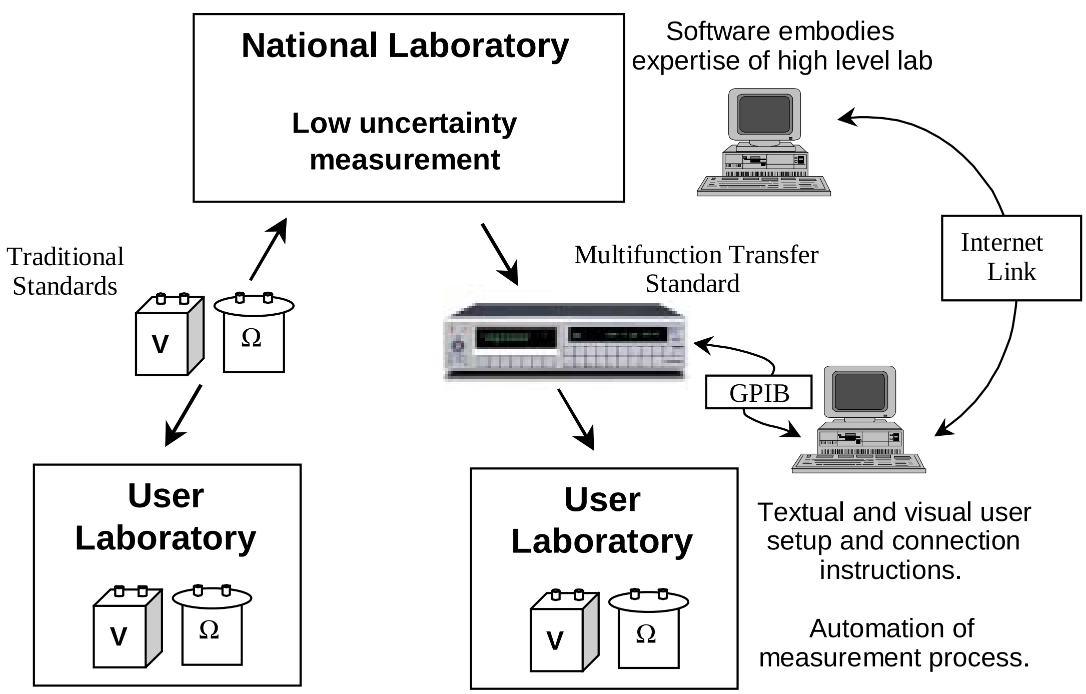
Introduction:

Most laboratories maintaining devices such as voltage references and standard resistors as their highest level standards and means of providing traceability. Typically they send these standards to the National a higher echelon laboratory for calibration, or they may have separate transfer standards that are sent out and intercompared with the laboratory standards on their return. In many cases the laboratory will not have the ability to realize the full potential of the very low calibration uncertainty that is provided when the standards are calibrated. The standards themselves may have poor long term stability, be adversely affected by transportation, or the laboratory's measurement practices and expertise may be less advanced. Consequently the monetary investment in calibration fees may not bring the return that they may otherwise do if the laboratory were better able to make use of the low measurement uncertainty provided employing similar best measurement practice in their own use of the standards on their return from calibration.

Furthermore, the process of importing traceability for multiple values of several different parameters requires many individual devices to be sent out for calibration.

What if a single device could be used to provide traceability for all the parameters at multiple values simultaneously, and if the measurement process were controlled and not reliant on the level of skill and expertise present within the laboratory?. A number of benefits could be possible:

The overall uncertainty could be less because the full potential of the low measurement uncertainty applied to the calibration of the transfer standard at the higher echelon lab could be passed on to user laboratory with another low uncertainty measurement when the intercomparison takes place with the user lab's reference standards – lower than would be achieved with the traditional approach. Instead of requiring a number of individual standards to be packaged, shipped, and measured a single multi parameter transfer standard would simplify the physical and administrative issues. Cost effectiveness of the process would be improved. If the measurement could be monitored and controlled by the higher echelon laboratory it could handle the more complex measurement issues that the user lab may have difficulty with, for example applying corrections for temperature coefficients of the transfer standard and the laboratory temperature, and calculating measurement uncertainties.



Comparison of traditional and alternative approach to traceability import using multifunction transfer standard under remote control instead of individual standards.

The author's organization is co-operating with the UK National Physical Laboratory in a joint project to investigate and demonstrate such an approach using a multifunction transfer standard and making use of the internet to provide control and automation of the measurement and data processing. An outline of a possible measurement scenario and software structure is presented in this paper. Attendant issues including monitoring and security are discussed. At the time of writing the project is at an early stage, however it is expected that when the paper is presented the project will be sufficiently advanced to be able to describe and demonstrate the results in detail.

The Transfer Standard:

The Wavetek-Datron model 4950 multifunction transfer standard was designed as a device for calibrating multifunction calibrators, by acting as a transfer between traditional laboratory references and the target calibrator located remotely. It has also found application as an audit standard for interlaboratory comparisons and proficiency testing. The application described in this paper may be considered as an extension of the latter applications, by providing traceability from traditional laboratory standards to other similar devices located at remote laboratories. The 4950 is capable of measuring DC and AC voltage, DC and AC current, resistance and frequency over a wide range of values. Each measurement point is individually calibrated, reducing uncertainty contributions to the 4950’s stability with time and temperature. Despite the device having stability specifications slightly larger in some cases than the best performance achieved with devices such as zener references and standard resistors, the overall uncertainty which can be realized within the user’s laboratory is still likely to be better than would normally be achieved because of the control and techniques for measurement.

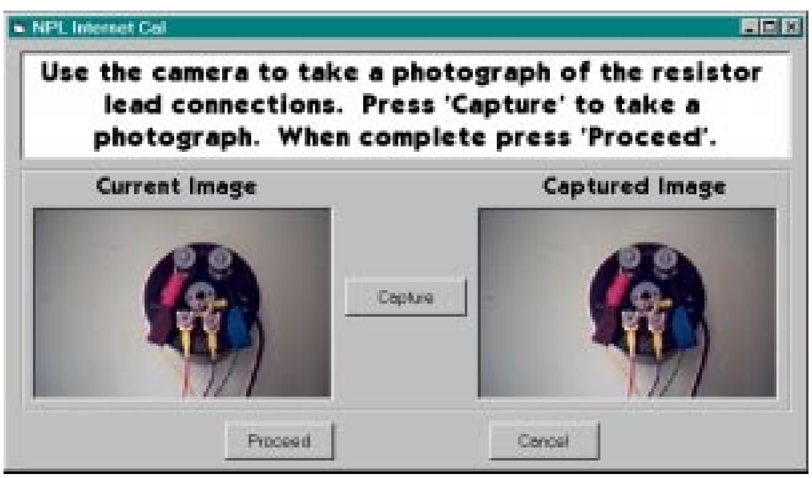
The 4950 has additional features and accessories that are helpful in this application. A power on warm-up feature can be used to prevent measurements being taken until the device has been powered up sufficiently long to stabilize. It has a built in temperature sensor that can determine and report the environment temperature and a PRT probe accessory can be used together with the instrument resistance measurement function to determine the temperature of any resistance standard being used, even if the resistor is located in an oil bath.

Measurement Control via The Internet:

Automated systems usually involve software installed on a computer used to automate the measurement process, including any post processing of data, to apply corrections for the standard, calculate measurement results, and nowadays provide an uncertainty value. If the systems are not commercially available users must write their own software and the software must be thoroughly evaluated to ensure it functions correctly and results are valid. If subsequent revisions are made or later versions become available these changes must also be tested and it can become an onerous task to keep multiple copies of the same software installed on several systems all up to date with the latest version. An alternative might be to make use of the Internet to provide the software control. If a central, approved, site maintained the software the issues of testing and evaluation, maintaining the latest version, and expertise can be addressed once with all users benefiting.

If that site were operated, for example, by the National Lab, users could subscribe and then obtain access to make use of the software when the measurement was needed and be confident of the validity of the method and software, and currency of the version. In practice the process could be initiated by the service provider sending out the calibrated transfer standard, or by the user requesting it be sent out. On its arrival, the user could set up the internet connection and automated measurement would take place. There aware a number of detailed scenarios for the software architecture and structure, some are discussed later, however it would be necessary that the transfer standard, computer and software supported a common interface capability or capabilities. For this project and the sake of simplicity IEEE488 GPIB will be used, together with a specific GPIB interface card within the PC to avoid the complexity of having to handle PC interface driver software configuration via the internet.

In addition to the benefits already described, the audio and video capabilities of an Internet link enable an online 'on-demand' consultancy or help service to be easily integrated within the process. If used, this feature that would allow experts at the provider site to oversee the process, issue instructions, or ask questions whilst viewing any aspect of system layout or interconnection via a webcam. Such facilities are extremely low cost and commonplace – many homes now have internet enabled PCs with webcams for families to keep in touch around the world – when relatively recently only the large multinational businesses could justify the expense of videoconferencing facilities. In addition to allowing users access to expert help, another application might be monitoring within assessment and proficiency testing activities.



Example dialog box instructing user to take photograph of connections with a webcam attached to the user's PC.

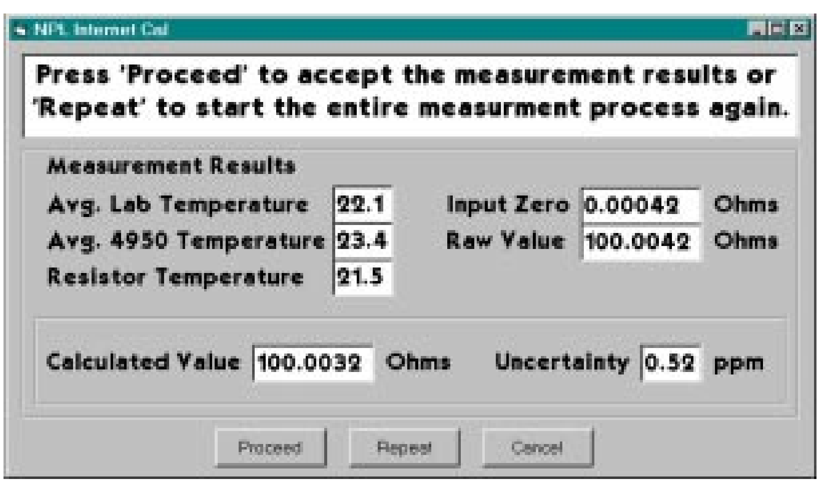
Software architecture and operation:

Alternative structures are possible, with the session or process being initiated by either the provider or user. Software for the automation could be downloaded to the user's computer, or the user's computer could become a simple control interface with the measurement software residing at the provider’s end of the link. For the majority or measurement scenarios having the users PC as a simpler remote control interface and retaining the measurement and process control software at the providers end is preferable. This requires the minimum of software on the users PC, to be transmitted or otherwise transferred for installation and removed once the process has been completed. The software must address a number of functions:

To set up the measurement session, gather information about the user and standards to be measured such as lab name, location manufacturer and model numbers, serial numbers, etc. This could be achieved with relatively simple HTML pages being transferred between provider and user’s PCs. In a sophisticated realization, a database could support retention and availability of historical data for the standards, allowing additional capability for data analysis, such as curve fitting and drift rate determination, to further enhance scope of such a system.

The software must then control the measurement process and any additional activities such as video capture and transmission from a digital camera. The transfer standard is fully programmable, but the laboratory standards being considered in this example have no capability for automation, although conceivably some form of scanner or multiplexer could be included in the system. The user will receive textual and visual instructions to make the necessary manual setups and interconnections.

The measurement portion of the software would take the form of an ActiveX control that would be downloaded as part of a web page and registered on the user’s computer, allowing it to take control of the measuring instrument via a GPIB card, and control the digital camera (if one was connected to the user’s PC). The ActiveX control would contain the series of user prompts directing the user through a set of procedure steps. At each stage several options would be open to the user, confirmation would lead the user to the next step, cancellation would stop the measurement process, and repeat would allow the user repeat a particular step. Once the procedure was complete, the relevant measurement data would be returned via the internet to the provider’s computer where it could appended to any previous measurement data and used in data processing.



Example dialog box displaying measurement results, with option to repeat the measurement process.

All communications between the client and the provider's computer would be via the TCP/IP protocol used by almost all PCs, however data encryption could be added if worries of external 'interference' were a concern.

Conclusion:

One of the major benefits of the proposed approach is to improve the uncertainty that can be realized within a user's laboratory by the automation of the traceability import process between that laboratory and the organization from which it obtains traceability, and at the same time reduce the cost and complexity of the process. Using a multifunction transfer standard to simultaneously provide traceability, for example, for DC Voltage and Resistance, can significantly simplify the process – not only from a technical perspective, but also simplifying the scheduling, administration and shipping issues by replacing several transfer standards with a single device. The Internet and today's computer and information technology can provide an ideal medium for controlling and automating the measurement process, transmitting data, and giving worldwide access to centers of expertise. The ability to automate measurement and data processing at a distance has significant potential to improve uncertainties by bringing best measurement practice to organizations that would otherwise lack the capability. Instruments like the 4950 Multifunction Transfer Standard provide the required functionality to make this practical in the DC & Low Frequency electrical calibration area in a cost effective manner. When presented, this paper will include details of experiments performed to investigate and demonstrate this approach in practice.