# Internet-Based Test Service for Multifunction Calibrators

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### *Abstract*

*A new method of providing traceability for multifunction calibrators (sources used to calibrate digital multimeters) is described. The method requires a transportable digital multimeter that links a reference calibrator to the calibrator under test and an Internet connection to share test procedures, software, and data. Digital cameras and microphones at both ends enhance communication for troubleshooting and collaboration.*

## 1. Introduction

Multifunction calibrators are used to test and verify the accuracy of digital multimeters (DMMs) that are used in a wide variety of industrial applications. In many cases these calibrators require traceability to nationally and internationally accepted electrical standards. Like DMMs, calibrators operate over a wide range of ac and dc voltage, current, and resistance, and it is virtually impossible to test all available outputs. One approach is to calibrate them using two or three electrical standard artifacts and rely on 'self-calibration' software in the calibrator to compensate for errors over the entire parameter space. This is rather painless for the calibration technician but many users are uncomfortable relying on this 'self calibration' feature. Another approach is to calibrate as many points as possible (> 200) using standard artifacts (zener references, resistors, and thermal converters) and then interpolate between points to estimate uncertainties over the entire parameter space. Most users are more comfortable with this method but, even with semi-automated systems [1,2], it can take a skilled technician up to a week to complete such a test. A third approach, one that is gaining popularity, is to use a transportable DMM. The DMM is characterized using an artifact-calibrated calibrator or 'reference calibrator' maintained at a national laboratory or an accredited standards laboratory. This approach limits the laborious artifact calibrations to a few laboratories. The calibration of the transportable DMM can be almost completely automated and, if it does not degrade during shipping, it's possible to calibrate the remote 'test calibrator' at nearly the same level of uncertainty as could be achieved with an artifact calibration. Traceability is provided through a test report for the transportable DMM.

### 1.1 Measurement Assurance Program

For many years, the National Institute of Standards and Technology (NIST) has provided what is called a Measurement Assurance Program (MAP) for a number of electrical quantities [3]. The philosophy is that it is more valuable to calibrate the customer's calibration process than the transportable standard. In a typical MAP, a NIST-owned standard is calibrated and then shipped to the customer where it is calibrated as an unknown, the standard and test data are then returned to NIST where a follow-up calibration and data analysis are performed. A calibration report is issued for the customer's test system rather than the transport standard. Communication between NIST and the customer during the test is by telephone or email. Since the data is returned with the standard, if something is done incorrectly, the usefulness of the calibration is diminished and the standard may have to be returned to the customer for repeat measurements.

## 2. Internet-Based Calibration Service

A new service is evolving at NIST in which a customer's process can be monitored by NIST staff during the test. It employs the Internet to expand present capabilities, making the process not only more efficient but also more collaborative. For example, to provide traceability for a customer's calibrator, a customer-owned DMM is tested using that calibrator, the DMM is shipped to NIST where it is tested using a NIST reference calibrator, and it is returned to the customer for follow-up tests. An interactive Internet link between NIST and the customer is established to improve communications, allowing the customer to transfer test data and download test procedures and control software for system evaluation. With digital cameras and microphones at each location, NIST can

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provide real-time consultation and assist with troubleshooting during the test. The customer's 'before' and 'after' data are sent electronically to NIST where the data analysis is performed. Once completed, a password-accessible report (that expresses the test calibrator errors and uncertainties in terms of the NIST reference calibrator) may be posted on a NIST Web site. The status of the system can be monitored by periodic comparisons between the customer's calibrator and DMM. In the future, the electronic test report and uncertainty statement may be updated based on these comparisons. A database of test systems with historical data and instrument models should make it possible to better predict performance and determine the calibration interval based on uncertainty requirements. A block diagram of the calibration process is shown in Fig. 1.

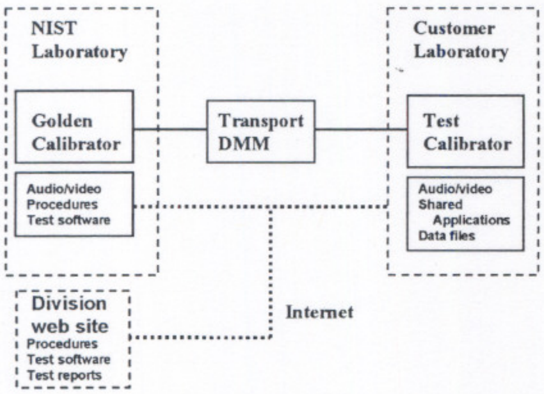


**Figure 1.** Block diagram of the test system. Audio/video/data link made using digital cameras, microphones and video conferencing software.

## 2.1 Video Conferencing Software

Commercial video conferencing software (based on the International Telecommunications Union standard H.323) is used to establish the link between the Internet Protocol (IP) addresses at the two laboratories. This software takes advantage of the available bandwidth to provide audio and full motion video between two users. Multiple users can observe shared applications and collaborate (to actually control a shared application). Files are easily transferred between participants and sessions can be documented on multi-user whiteboards and chat boxes. A typical computer screen image with some of these capabilities is shown in Fig. 2, where a shared spreadsheet with test data is shown in the background, the video conferencing panel with images from two participants on the right, a chat box on the left, and an electronic notebook storing test parameters and photos of critical connections in the foreground.

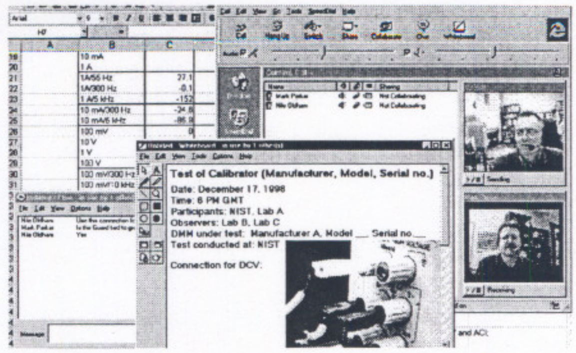

**Figure 2.** Screen image showing the use of video conferencing techniques to enhance communication with test clients.

## 2.1 Webpage

A NIST webpage is used in conjunction with the video conference to provide additional resources for remote calibrations. This site has downloadable test procedures and test software that can be used to confirm that the control software used by the test laboratory implements the procedures properly. In addition, clients will be able to view and download their password-accessible test reports and schedule future tests.

## 3. International Comparisons

While originally intended as a tool to enhance NIST/client calibrations, the technique has also been used to facilitate an international comparison of electrical units within the Interamerican Metrology System (SIM). This comparison uses high-end DMMs as traveling standards to measure five electrical quantities: dc voltage, dc current, ac voltage, ac current, and dc resistance. In this application where many different calibration techniques are used to test the traveling standard, it is particularly important to have well defined procedures. It is much easier to describe a test set-up and connections by sending a high-resolution image accompanied by lower resolution video, along with a verbal and/or written description. It is also helpful for comparison participants to observe techniques and procedures used at other National Metrology Laboratories (NMIs). Twelve NMIs within SIM now have identical systems (computers, software, cameras, and microphones) with which to conduct comparisons. In the future, all SIM members will have such systems. An H.323 server, presently maintained at NIST, extends the capability of the video conferencing software to provide voice-activated, multi-user audio and video, allowing multiple participants to observe a comparison between two NMIs. The system, dubbed 'SIMnet,' can operate at LAN speeds or as slow as 28.8 kbps. A description of this program including proposed procedures for Internet-enhanced international comparisons, downloadable verification software, and test results can be found at the NIST SIMnet-DMM web site.

## 4. Conclusions

The advent of inexpensive video conferencing software and digital video cameras, coupled with ever-increasing bandwidth, has made it feasible to use the Internet to greatly enhance measurement science. It is now possible to have a reasonably good audio and video and excellent data communication between laboratories around the world for little more than the cost of a desktop computer and an Internet service.

The use of this technology has been demonstrated for the calibration of DMMs and calibrators. This study is being conducted in collaboration with DMM users and manufacturers and other national metrology institutes to determine how best to use the Internet to provide added value to calibration services for programmable instruments, and to help define communication and testing protocols. Its use in other areas of metrology is yet to be determined, but there is no doubt that it will have a major impact.

## Acknowledgements

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## References:

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