THE DESIGN OF A FULLY AUTOMATED SYSTEM FOR THE CALIBRATION OF ELECTRONIC AC/DC TRANSFER INSTRUMENTS.

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Introduction

AC/DC measurements at NPL are currently carried out using a computer-controlled system [1]. This system allows for fully automated measurements following the manual range configuration of the measurement circuit for a given applied voltage.

This paper describes a new system that will allow for the full automation of an AC/DC transfer calibration including automated certificate production.

Electronic AC/DC Transfer Standards

The majority of AC/DC Transfer instruments are of the electronic form where readings and ranges can be manipulated using the IEEE-488 interface. Whilst these electronic instruments lend themselves to use in automated measurements system, the NPL standards consist of a thermal element plus a ranging resistor [2], which need to be manually changed prior to a given test.

Some electronic standards have been found to be highly stable and suitable for use as a transfer standard in a calibration system. When calibrated directly against the NPL multi-junction converter standards, these electronic standard can be used with comparable uncertainties to the NPL single-junction converter working standards that are currently used in a calibration.

An example of a highly stable electronic standard is a Fluke 792A. Monitoring of the drift history for one such device has shown its suitability for a potential secondary working standard to take the place of the NPL single junction devices. However, with regard to full automation using a 792A, the problem with this type of device is that its ranges cannot be changed using the IEEE bus; range changing being accomplished manually using a hand-turned rotary switch.

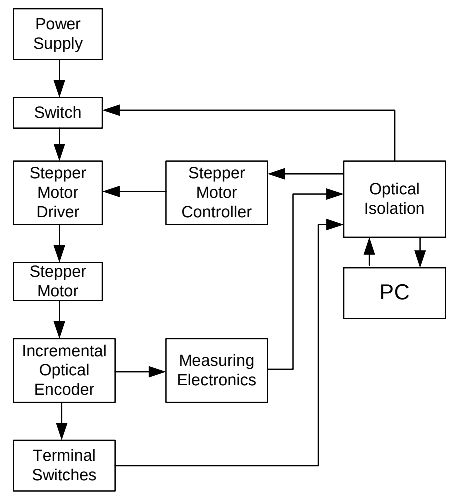
Computer Controllable Range-Changing Using A stepper motor.

In order to overcome the lack of remote controllable range changing on the 792A, a stepper motor system has been built that will turn the rotary switch which will select the range on the 792A.

Figure 1 shows the block diagram of the stepper motor control unit (SMCU). The SMCU, which is a digital closed loop control system, is controlled via an optical isolated parallel port interface.

Figure 1 Stepper motor control unit block diagram

The stepper motor position will be controlled by a stepper motor controller (L297) and a driver (L298). The position of



the stepper motor is measured relevant to a known initial position using an incremental encoder. From the in-phase and the quadrature-phase signals of the incremental optical encoder, the incremental position and the direction of motion can be determined by using one counter and one D-type flip-flop.

Two switches (terminal switches) are attached on the terminal positions of the DUT shaft to prevent damage of the DUT under fault conditions of the stepper motor.

An Automated AC/DC Transfer System

The stepper motor system can be used in conjunction with the existing automated system at NPL [1] to produce a fully operated system for the calibration of electronic standards.

Using the 792A as a working standard, voltage levels in the range 0.1 V to 100 V can be selected automatically. The ability to automatically select the range of the standard and the device under test (DUT) will reduce calibrations times considerably. Currently, a full re-calibration of a transfer standard would typically take 15 to 20 days measurement time plus an additional 5 days to analyse the results for the certificate. Using the fully automated system and automated certificate production it is estimated that this time can be reduced to 10 days. Further, automated measurements allows for an increased number of measurements to be readily taken during a calibration. In some cases this can reduce measurement scatter and improve uncertainties.

Another advantage of using the 792A compared with traditional working standards is its built-in overload protection, thus reducing the likelihood of damage.

For voltages above 100 V, the NPL system uses an additional amplifier and special relay drive unit. The Fluke 792A also requires an external ranging resistor for voltages above 220 V. This manual configuration limits automation up to 100 V.

Below 0.1 V, NPL uses specially constructed potential dividers. In the existing system these dividers need to be individually characterised for each calibration. By calibrating the 792A mV ranges against the divider based system and making the required loading corrections the 792A can be used as a working standard in this range.

The Fluke 792A is battery operated and requires daily charging. By using an isolated power supply[1] will allow the Fluke 792A to be powered continuously.

Automating Calibrations and Certificate Production

The automation of measurements is controlled using Windows-32 software.

In preparation for the calibration, the details of each measurement including all of the voltage ranges and frequencies to be measured will be entered into an electronic calibration agenda in the form of a spreadsheet-like input grid.

During the calibration, the control-program will select the required range on the NPL standard 792A using the stepper motor system. The DUT ranges will also be changed as directed by the agenda.

For each range/level selection in the agenda, the selected sets of frequencies will be used to obtain the calibration points. Results from the DUT and standard will be transferred using the IEEE-bus for collation and processing using the least squares methods detailed in [1].

AC/DC transfer calibration certificates can contain hundreds of measurement results and uncertainties all of which need to be compiled and checked. The new system automatically compiles certificate tables directly from the results of the automated measurements. Using Microsoft's inter-process communication protocol known as *object linking and embedding* (OLE), the software automatically compiles the certificate results into correctly formatted tables in an Excel spreadsheet. Using OLE links to the spreadsheet based uncertainty budget, the program automatically interrogates the budget for the latest Type-B uncertainties combining them with the Type-A contributions of the DUT to calculate the uncertainties and degrees of freedom for each measurement.

Automatic certificate production is should not only reduce the time taken to compile the certificate, but also eliminate transcription errors as the results are taken directly from the data file into the certificate.

Conclusion

The design of a new fully automated calibration system for AC/DC transfer is described utilising stepper motor range changing and automated certificate production. It is anticipated that this system will significantly improve turn-round times and certificate accuracy.

Acknowledgements

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References

[1] Digital bridge for comparison of AC/DC transfer instruments, R B D Knight, D J Legg and P Martin, IEE Proceedings A, Vol. 138, No.3, May 1991.

[2] Components and systems for AC/DC transfer at the ppm level, P Martin and R B D Knight, IEEE Trans. Instrum. & Meas., Vol. IM-32, No.1, March 1983.

[1] Metron Designs Ltd. isolated dc power supply.