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Test driving the Wiltron 36581NNF  
AUTOCAL ANA calibrator

J P Ide

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Comments on this report should be sent to:

mail:            **ANAMET  
Building 72  
National Physical Laboratory  
Queens Road  
Teddington  
Middlesex  
TW11 0LW**

fax:             **0181 943 7176 (UK)  
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Test driving the Wiltron 36581NNF AUTOCAL ANA calibrator.

<sup>1</sup>J P Ide, DERA, St Andrews Road, Malvern, WR14 3PS.

## Abstract

The Wiltron 36581 AUTOCAL calibrator is a device that allows the complete calibration of an ANA with a single connection. A variety of different, known terminations are electronically connected in the correct sequence to allow the error equations to be solved. The error coefficients are calculated at each frequency enabling full error correction. This report is an account of some experiments performed using one of these devices to correct a Wiltron 37369A ANA. The calibrator was fitted with type-N male and female connectors, making it fully insertable, and was specified over the frequency range 40 MHz to 18 GHz.

## Introduction

The opportunity to play with some completely new technology comes but rarely, so I eagerly grasped the opportunity presented when Anritsu-Wiltron loaned the RF and Microwave Impedance Section at NPL Malvern a AUTOCAL calibrator for evaluation. They were kind enough to do this in the full knowledge that an ANAMET report on its performance would probably be published, this indicates a lot of confidence in the product as I am not renowned for pulling my punches.

The concept behind the calibrator is disarmingly simple. To determine the error coefficients in an ANA a selection of known loads are placed in sequence on the test ports, the responses are taken into a program running on a PC and from the responses and the known values the coefficients required for error correction can be calculated. These error coefficients are then fed back into the ANA to complete the process.

The entire system consists of a calibrator module and its power supply, a PC running Windows 3.1 or later with a GPIB card and a cable attaching the module to one of the PC serial ports. The GPIB card is necessary to enable the PC to control the ANA during the calibration process. For this investigation I was also running SOFTPLOT [1] to extract and display the measurements. Using SOFTPLOT enabled me to save the data and also export it to EXCEL [2] to create the plots in this report.

The module loaned was a Wiltron 36581NNF running with version 1.4 of the AUTOCAL software. This module is specified as functioning over the range 40 MHz to 18 GHz and the documentation claims that the directivity and load match errors will be better than 38 dB with the source match better than 34 dB. The transmission tracking is specified as better than  $\pm 0.20$  dB or  $\pm 0.1$  dB depending on the type of 'through' selected during the calibration.

For a two-port calibration the module offers a 'known' through path, however the software offers the option of performing the through connection by disconnecting the module and joining the ports directly. Wiltron call this type of calibration 'True thru' as distinct from the 'Module thru' described above.

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<sup>1</sup>The author was on loan to the National Physical Laboratory, Teddington, UK. at the time that this evaluation was performed.

Although there are other options available using the AUTOCAL system such as 1-port calibrations, Thru Update, and Adapter Removal, I did not examine the Thru Update or Adaptor removal due to constraints on my time, or perform any long term stability assessments.

### Setting Up

- i) Gauged the Type-N male and female ports on the AUTOCAL module. Female test port gauged as  $-0.001$ " which is within the specification of  $+0.000, -0.005$ ". The male test port did not register on the dial gauge. Visual inspection showed no shoulder on the pin. Damned funny connector! Decided to continue anyway as this situation was not one which could produce damage only concern at the quality of the connectors used.
- ii) Attached module power supply to module and mains supply. Checked LED labelled POWER was illuminated.
- iii) Attached semi-rigid K-connector cables to test ports on Wiltron 37369A, attached K/APC-7 and APC-7/Type-N adapters to end up with Type-N male as my test port 1 and Type-N female as my test port 2.
- iv) Checked the disk for viruses and loaded the Wiltron software under Windows control. Very simple. Ran the Wiltron software and under the 'Dialog' tab found the system setups necessary to change the GPIB and COM port settings. Not the place I would normally look for it but easy to do once you've found it!
- v) Connected cable from module to COM2 port on PC and GPIB cable from PC to ANA.
- vi) Selected 'Setup' tab and chose type of calibration as 2-port with port A of the module connected to port 1 of the ANA. Pressed CALIBRATE button and watched the instrument lights flash, pretty blue bars on the PC screen extend in length and the ANA display change in a bewildering fashion. Half a mo later the PC reported that the calibration was complete and that I could store the calibration info using the usual buttons on the ANA.
- vii) I replaced the module with a known item, called here the AUDIT item, measured it using the calibrated ANA and examined the data. It was not as good as I had hoped. There appeared to be a large phase offset (about 25 cms) and a small ripple on the magnitude that was disappointing.
- viii) I realised that I had carelessly misidentified the ports on the module and reversed them using SETUP. Reconnected module and performed calibration. Measured AUDIT item with excellent results. Repeated the connection of the module and recalibrated, and again, and again, and again, just for the fun of it!

### Operations Performed

- 1) 1-port calibration on male test port 1 at 101 frequencies from 40 MHz to 18 GHz using
  - a) AUTOCAL
  - b) Open-circuit, Short-circuit, Sliding/Fixed Loads (a conventional, manual calibration).

Plots are given of the comparative measurements performed of three different states of the AUTOCAL module (Figure 1) and one end of the AUDIT item (Figure 2). The results produced using AUTOCAL calibrations are shown using a dotted line. The traces show the responses of the three different items used by the AUTOCAL. This demonstrates that you don't need perfect values to perform a calibration, you only need the three values to be *different* and *known*. The scale of the first plot precludes an assessment of how well the two calibration methods agree. For the AUDIT item the AUTOCAL calibration produced a response that varies more rapidly with frequency than

the fixed/sliding load (manual) calibration. The differences around 11 GHz are the most marked.

- 2) 2-port calibration at 180 frequencies from 100 MHz to 18 GHz using:
  - a) AUTOCAL with 'module through'
  - b) AUTOCAL with 'true through'

Plots are given of the comparative measurements of S11 magnitude (Figure 3) and phase (Figure 4), S21 magnitude (Figure 5) and phase difference (Figure 6). These plots include the calibrated values for these parameters with their associated uncertainties shown by error bars. The transmission phase is normalised by subtracting the calibrated value at the selected frequencies from the values measured using the 'module thru' and 'true thru' calibrations because without this the scale of the plot would have to be set to  $\pm 180^\circ$  and this would swamp any differences.

The traces for the 'True Thru' and 'Module Thru' in Figures 3 & 4 overlap completely indicating that the differences between the two calibration techniques do not affect the measurement of reflection coefficient.

## Conclusions

The AUTOCAL system is easy to set up, easy to use and gives surprisingly good results. My only complaint is the use of strange non-precision, out-of-specification Type-N connectors on the version that I was loaned.

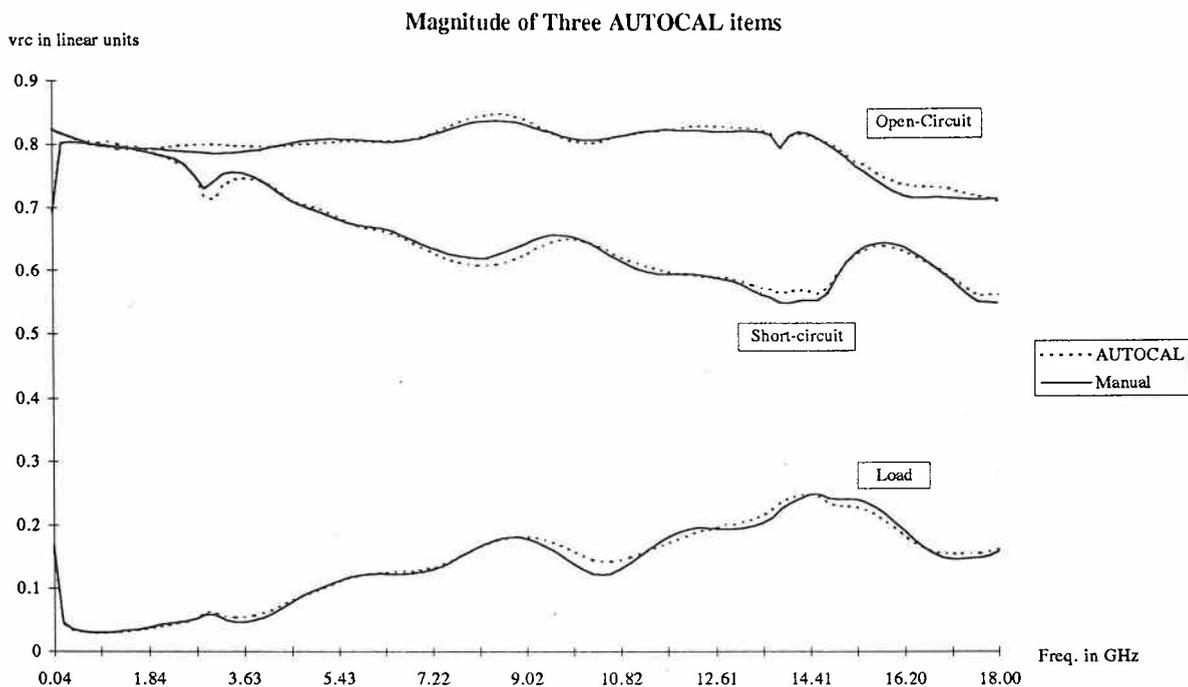
It seems ideally suited to the manufacturing, test and shop-floor situations for which it was designed.

## Verdict

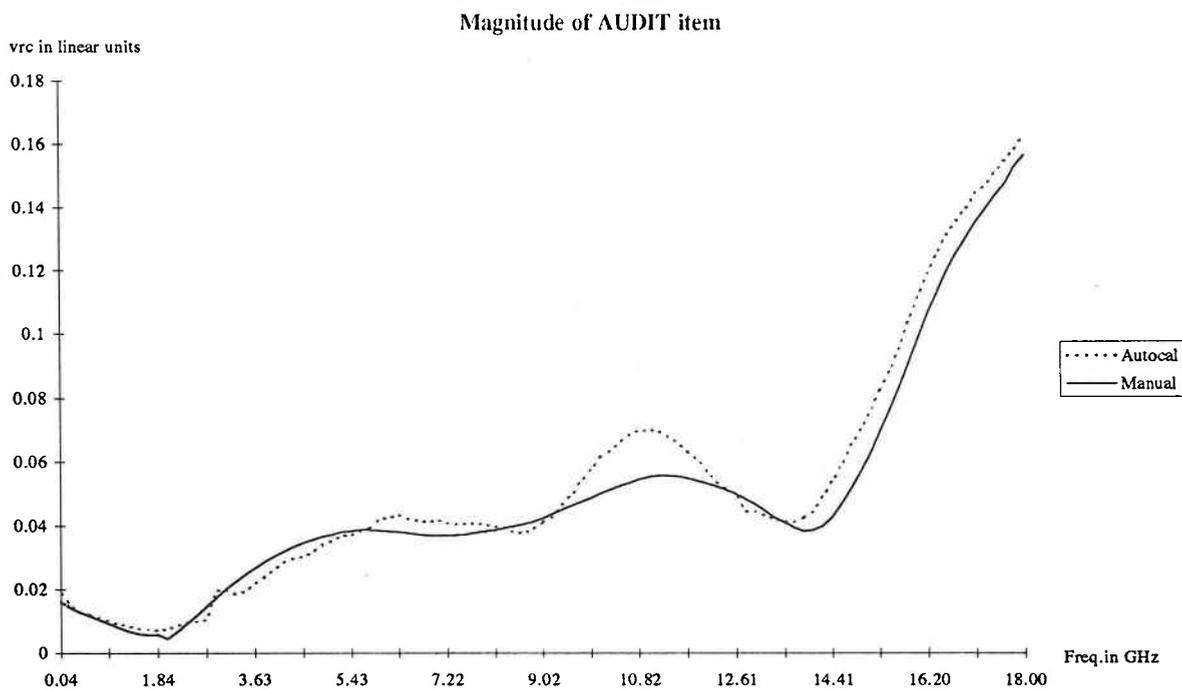
If I had to perform lots of low-level calibrations on ANAs on a routine basis then I would have no hesitation in using such a system. It takes a lot less skill to produce acceptable results. Establishing the traceability in a calibration environment might prove problematical but I predict that someone will attempt it. Overall, thumbs up for a neat system.

## References

- [1] SoftPlot Measurement Presentation Software, P & H Technology Consultants, 10 Teversham Rd, Fulbourn, Cambridge, UK, CB1 5EB.
- [2] EXCEL, Microsoft Corporation, 16011 NE 36th Way, Box 97017, Redmond, WA 98073-9717, USA.



**Figure 1** Plots of three different calibration states of the AUTOCAL module with AUTOCAL and fixed/sliding load (manual) calibrations



**Figure 2** Plot of magnitude of AUDIT item with AUTOCAL and fixed/sliding load (manual) calibrations.

AutoCal Measurement of Reflection Coefficient Magnitude of Audit item

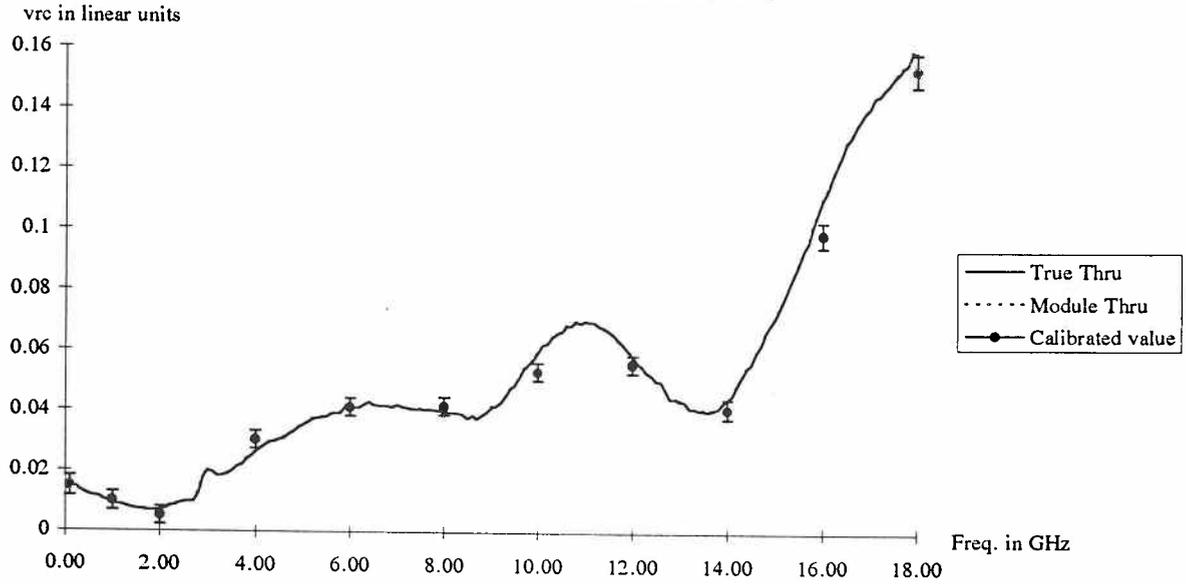


Figure 3 Magnitude of AUDIT item using AUTOCAL and calibrated values

AutoCal Measurement of Reflection Coefficient Phase of Audit item

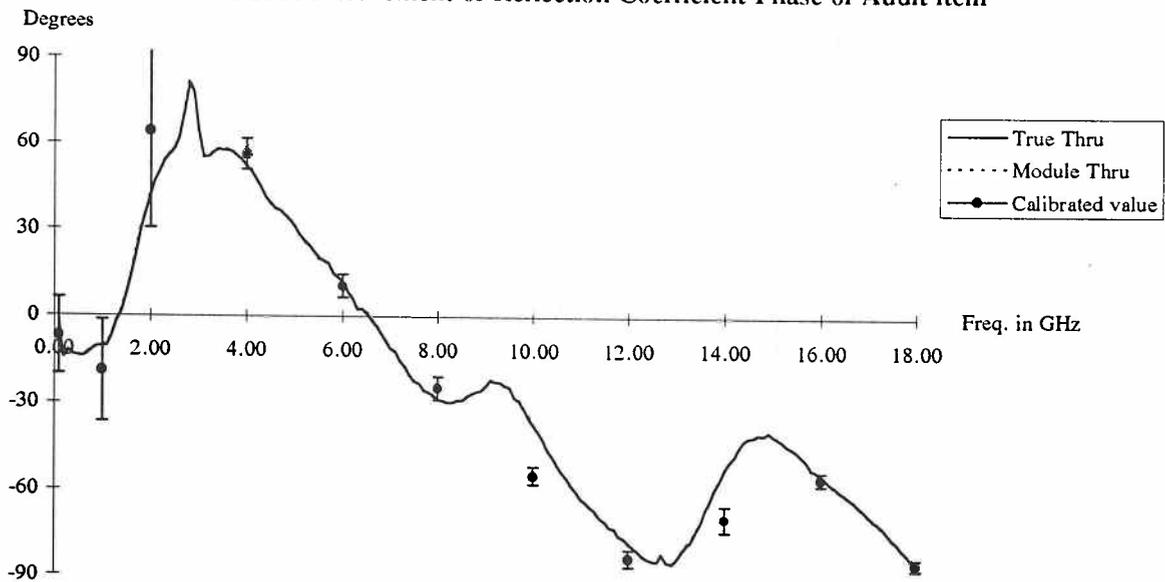
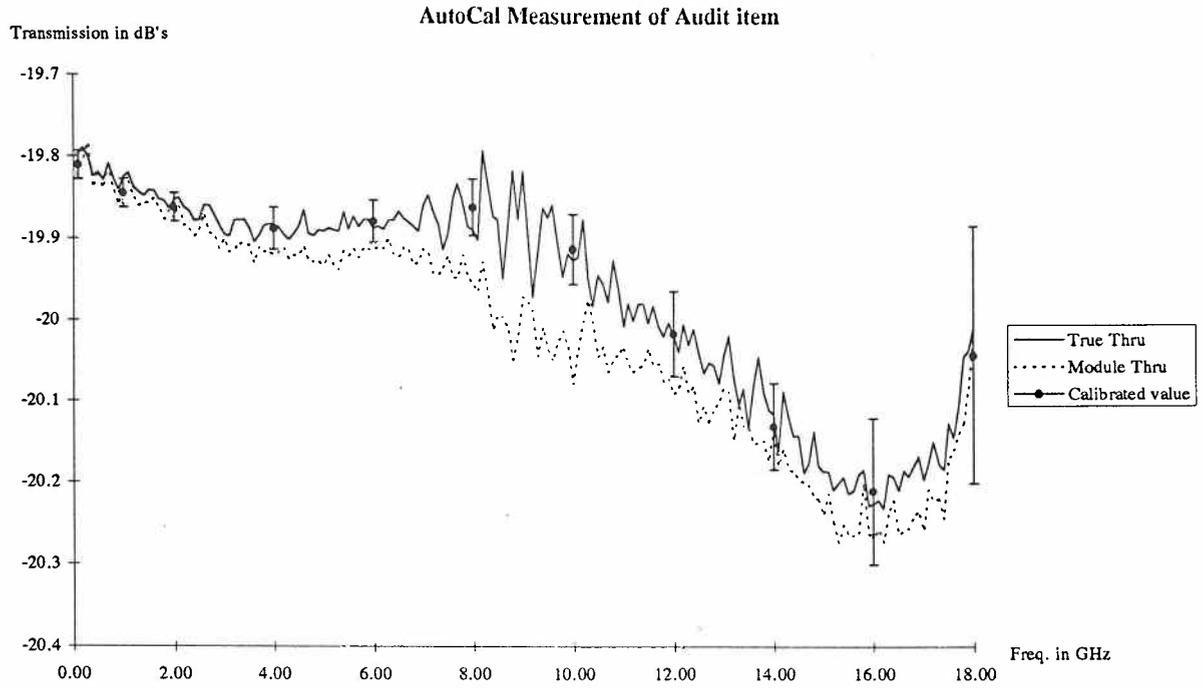
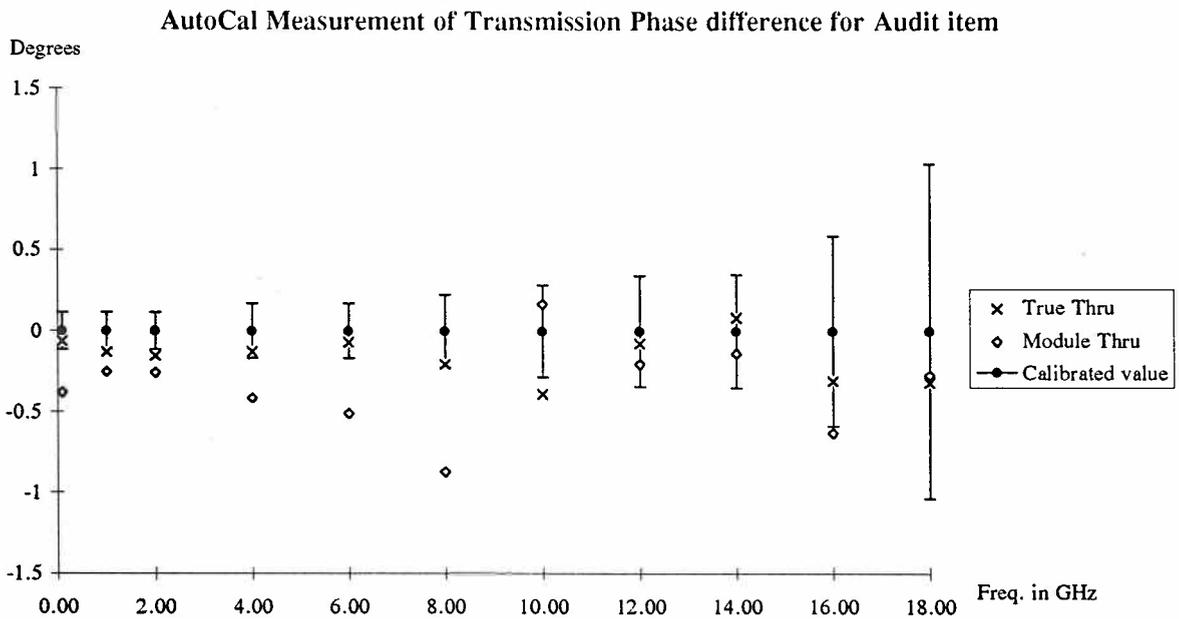


Figure 4 Phase of AUDIT item with AUTOCAL and calibrated values



**Figure 5** Transmission of AUDIT item with different AUTOCAL calibrations and calibrated values.



**Figure 6** Differences in phase for AUDIT item between different AUTOCAL calibrations and the calibrated values.