# AN AUTOMATED TEST FACILITY FOR NEUTRONIC AMPLIFIERS

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## 1.0 INTRODUCTION

Neutronic amplifiers are used at the Chalk River Laboratory in applications such as neutron flux monitoring and reactor control systems. Routine preventive maintenance of control and safety systems include annual calibration and characterization of the neutronic amplifiers. An investigation into the traditional methods of annual routine maintenance of amplifiers concluded that frequency and phase response measurements in particular were labour intensive and subject to non-repeatable errors. A decision was made to upgrade testing methods and facilities by using programmable test equipment under the control of a computer. In order to verify the results of the routine measurements, expressions for the transfer functions were derived from the circuit diagrams. Frequency and phase responses were then calculated and plotted thus providing a bench-mark to which the test results can be compared.

## 2.0 GENERAL DESCRIPTION

Tests are performed sequentially and the results are automatically tabulated upon completion.

The following types of test signals are available.

- D.C. LEVEL (voltage and current)
- STEPS
- RATES ( % rise/sec.)
- RAMPS ( V/sec. )

The following types of tests have been performed:

- FREQUENCY RESPONSE
- PHASE RESPONSE
- GAIN
- LINEARITY
- RISE TIME
- DELAY

A block diagram of the automated test facility is shown in Figure 1, the following test and measurement instruments are used:

- DYNAMIC SIGNAL ANALYZER
- SOURCE MEASURE UNIT
- DIGITAL MULTIMETER
- FUNCTION GENERATOR
- DIGITAL OSCILLOSCOPE

Switching between instruments and the amplifier - under - test is accomplished by means of a TWENTY CHANNEL HIGH DENSITY SWITCH SYSTEM.

The instruments are calibrated regularly to National Standards in accordance with the manufacturers' recommendations. Each measurement instrument is equipped with a self-check routine which must be completed successfully before a test can be carried out.

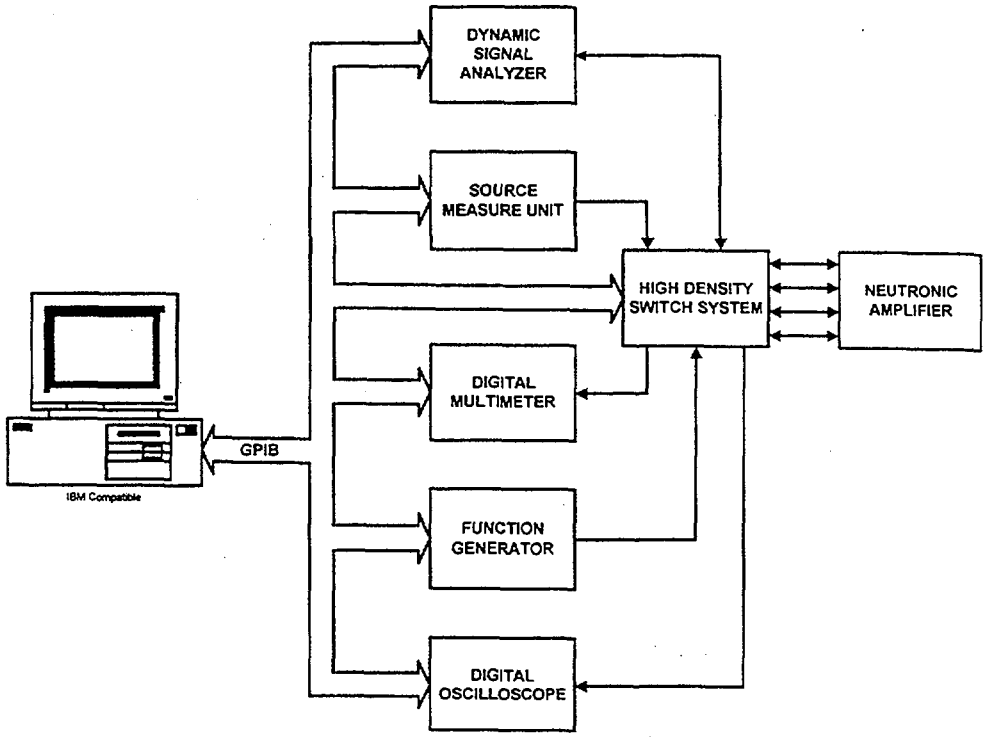



*Figure 1. Block Diagram of the automated test facility.*

Testing is controlled by Labview for Windows software operating on a Model 80486 Personal Computer (PC). A software quality assurance program has been established to ensure that revisions are controlled and documented and that the appropriate version is used for testing. The steps for implementing changes to the software are detailed in Figure 2.

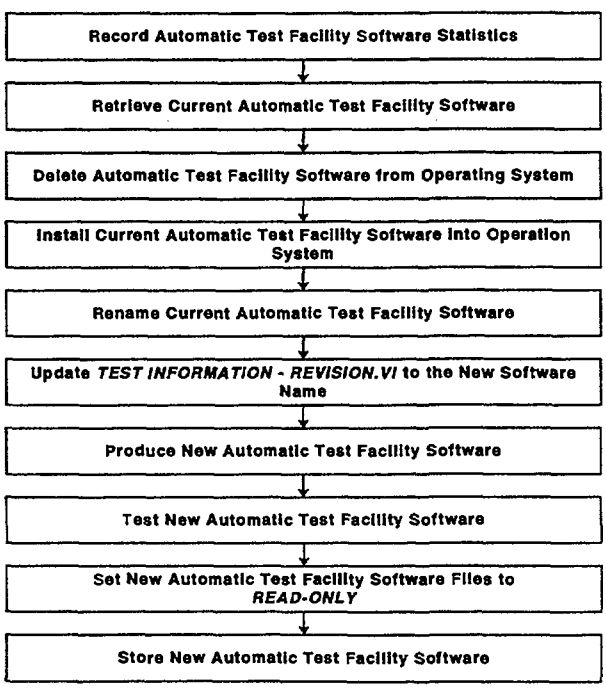



*Figure 2. Software Change Procedure*

The PC components are contained within a ruggedized industrial quality cabinet, all controls and indicators are secured behind a locking front panel door and are visible via a plexiglass panel. The keyboard is not normally connected to the PC, operator interaction is achieved by means of a mouse. The PC is configured as a stand-alone unit to prevent unauthorized access via a communications network.

The measurement and test instruments are connected to the PC by means of the General Purpose Interface Bus, results are tabulated on a graphics printer.

## 3.0 OPERATION

A summary of an amplifier test sequence is shown in Figure 3. Steps include:

- self diagnostics
- personnel identification
- identification of amplifier - under - test
- start test

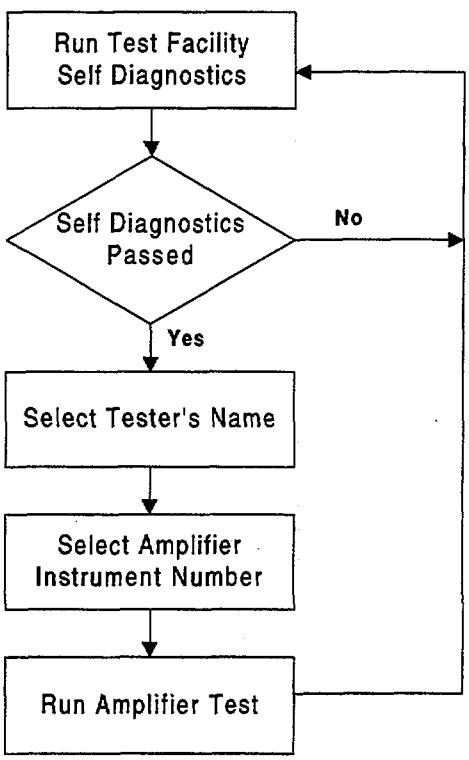
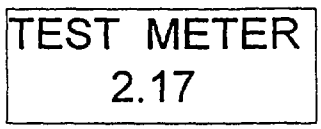



*Figure 3. Amplifier Test Sequence*

The operator is prompted at various stages of the test for such tasks as actuating switches or making changes to control settings on the amplifier-under-test. A typical operator prompt screen is shown in Figure 4 where an adjustment may have to be made in order to achieve the desired reading. The reading displayed within the box labelled 'TEST METER' actually changes as the adjustment is made.




**If TEST METER reads 2.2 +/- 0.1 Press** CONTINUE

**If TEST METER not within 2.2 +/- 0.1 complete the following:**

**1) Remove cover on KEITHLEY Log Picoammeter**

**2) Adjust R104 clockwise to increase or counterclockwise to decrease TEST METER reading to 2.2 +/- 0.1**

**3) Press** COMPLETE

*Figure 4. Example of Operator Prompt Screen*

In the event that a particular test will take some time to be performed, the operator is advised of the completion time, a typical example is shown in Figure 5.

SYSTEM RUNNING

OPERATOR NOT REQUIRED UNTIL

**Wednesday, April 09, 1997**

**3:43 p.m.**

*Figure 5. Display of Completion Time*

When testing is complete, the results are tabulated and printed in the desired format.

## 4.0 DISCUSSION

The automated test facility has been used to perform tests on the following types of amplifiers:

- ION CHAMBER
- LINEAR RATE
- LOG RATE
- LINEAR POWER
- LOG POWER
- MAGNETIC AMPLIFIER INTERSTAGE

The types and sequence of tests have been selected to ensure that all of the amplifier specifications are met. Test results must be approved by an authorized person before the amplifier is returned to service. An example of results which were found to be unacceptable is shown in Figure 6a.

**NRU CONTROL SYSTEM**
**LOGARITHMIC RATE AMPLIFIER AEP-5316**

**LINEARITY TEST**

Instrument No. A8870

| J1 INPUT (Volts / sec) | EXPECTED J4 OUTPUT (VDC) | ACTUAL J4 OUTPUT (VDC) |
|---|---|---|
| 0.000 | -0.05 to +0.05 | 0.0 |
| 0.089 | 14.3 to 15.9 | 16.3 |
| -0.178 | 28.8 to 31.8 | 32.5 |
| -0.267 | 43.1 to 47.7 | 49.1 |
| -0.089 | -14.3 to -15.9 | -16.1 |
| 0.178 | -28.8 to -31.8 | -31.1 |
| 0.267 | -33.0 to -41.0 | -35.6 |

COMMENTS: _____

_____

_____

Tested by: _____ Date: _____

Approved by: _____ Date: _____

*Figure 6a.*

In this case some of the measured values were found to be greater than the limits of the expected values, subsequent troubleshooting revealed a faulty component which was then replaced. The amplifier was re-tested and the results, shown in Figure 6b, were acceptable.

**NRU CONTROL SYSTEM**
**LOGARITHMIC RATE AMPLIFIER AEP-5316**

**LINEARITY TEST**

Instrument No. A8870

| J1 INPUT (Volts / sec) | EXPECTED J4 OUTPUT (VDC) | ACTUAL J4 OUTPUT (VDC) |
|---|---|---|
| 0.000 | -0.05 to +0.05 | 0.0 |
| -0.089 | 14.3 to 15.9 | 15.4 |
| -0.178 | 28.8 to 31.8 | 31.2 |
| -0.267 | 43.1 to 47.7 | 47.0 |
| 0.089 | -14.3 to -15.9 | -15.5 |
| 0.178 | -28.8 to -31.8 | -30.1 |
| 0.267 | -33.0 to -41.0 | -35.5 |

COMMENTS: _____

_____

_____

Tested by: _____ Date: _____

Approved by: _____ Date: _____

*Figure 6b.*

A typical input signal for a Log Rate amplifier is shown in Figure 7, the starting value, rate of increase and total duration have been pre-determined for a particular test.

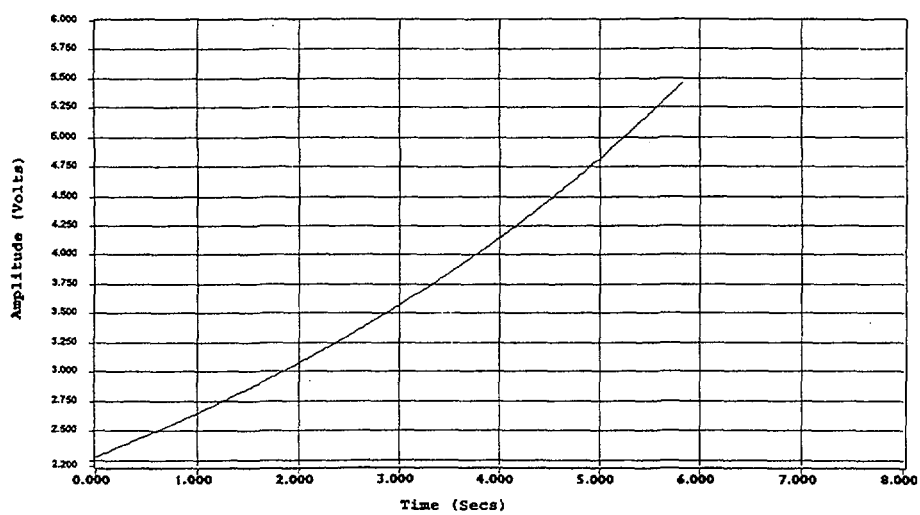



*Figure 7. Typical Rate Signal*

The signal is applied to the amplifier-under-test and the output is measured and plotted, see Figure 8.

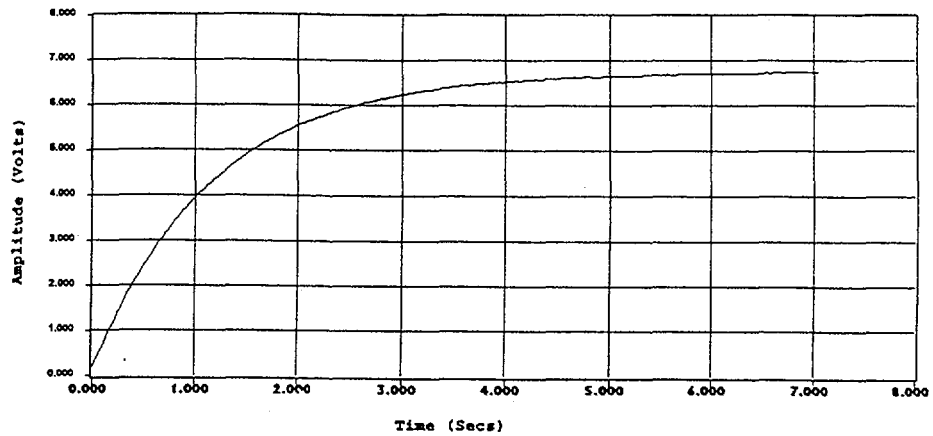



*Figure 8. Logarithmic Rate Amplifier Output*

The amplifier response shown in Figure 8 is compared to the theoretical response derived from the transfer function. The hard copies are stored and become part of the maintenance history of the amplifier.

The frequency and phase response plots of a magnetic amplifier interstage were produced using the Dynamic Signal Analyzer and are down in Figures 9 and 10 respectively.

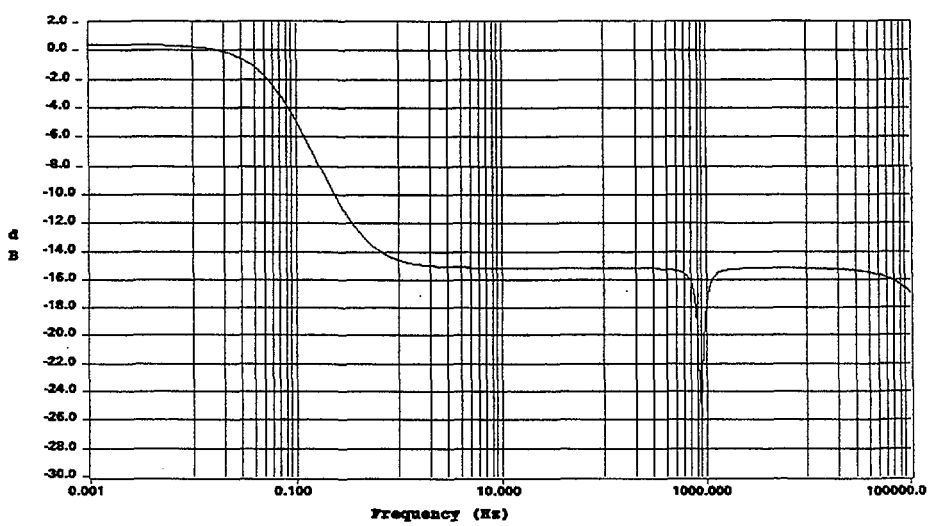



*Figure 9. Magnetic Amplifier Interstage Frequency Response*

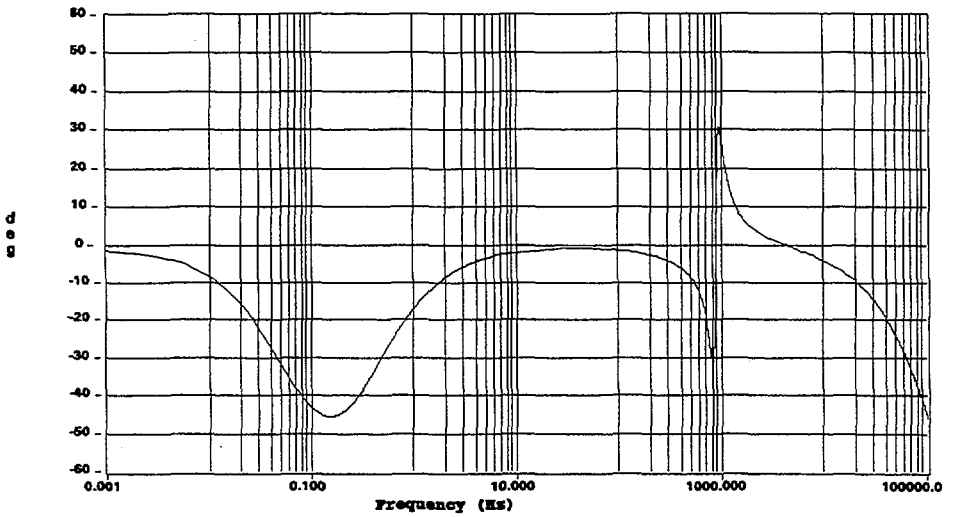



*Figure 10. Magnetic Amplifier Interstage Phase Response*

The response of this particular amplifier was considered interesting because of the notch filter at 800 Hz, a detailed study was performed on the circuit and the results used to verify the integrity of the automated test facility [1].

## 5.0 CONCLUSION

The automated test facility has been used for routine testing and characterization of a number of neutronic amplifiers. Advantages that have been noted are greater accuracy, repeatability, ease of use and a significant improvement over previous labour intensive testing methods.

Reference: W.J. BEATTIE, M.W. SELL, The verification of a test facility for reactor control system instrumentation. Atomic Energy of Canada Limited. AECL-MISC-393, 1996 May.