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SOFTWARE DEVELOPMENT FOR TRANSDUCER CALIBRATIONS

by
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CONTRACTOR REPORT

Prepared for

Defence
Research
Establishment
Atlantic

Centre de
Recherches pour la
Défense
Atlantique

DEFENSIO PER SCIENTIAM

Canada

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February 1997

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Prepared for

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Abstract

The report describes a research contract to develop transducer calibration software, referred to as TRANSCAL, for use in the Defence Research Establishment Atlantic (DREA) calibration facilities. The software implements a framework for these calibration procedures:

(1) Transmitting response using swept sine, pulse or CW.
(2) Receiving response using swept sine, pulse or CW.
(3) Directional response.
(4) Receiving response using pseudo-random noise.
(5) Reciprocity calibration.
(6) Receiving response for an array using swept sine, pulse or CW.
(7) Admittance measurement.
(8) Impedance measurement.

The TRANSCAL software controls the calibration procedure, acquires and processes the received data, and presents the results. The current version of TRANSCAL implements procedures 1 and 2 above. In addition, admittance and impedance measurements are incorporated into procedures 1 and 2. The system has been developed using the LabVIEW programming environment, to operate on a Macintosh Quadra 900.

Résumé

Ce rapport décrit un contrat de recherche pour développer le logiciel pour l'étalonnage de transducteurs, nommé TRANSCAL, utilisé aux facilités d'étalonnage du Centre de recherches pour la défense - Atlantique. Le logiciel établit une structure pour les procédés suivant:

(1) sensibilité en utilisant la fréquence de balayage d'une sinusoïdale, une impulsion ou une onde continue.
(2) sensibilité de réception en utilisant la fréquence de balayage d'une sinusoïdale, une impulsion ou une onde continue.
(3) directivité.
(4) sensibilité de réception en utilisant du bruit pseudo-aléatoire.
(5) réciprocité.
(6) sensibilité de réception d'une antenne en utilisant la fréquence de balayage d'une sinusoïdale, une impulsion ou une onde continue.
(7) mesure de l'admittance.
(8) mesure de l'impédance.

Le logiciel TRANSCAL contrôle le procédé d'étalonnage, acquiert et traite les données reçues et présente le résultat. La présente version de TRANSCAL inclus les procédés 1 et 2 mentionnés ci-haut. En plus, l'admittance et l'impedance sont incorporées dans les procédés 1 et 2. Le système a été développé pour un Macintosh Quadra 900 en utilisant l'environnement de programmation LabVIEW.

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Document Overview

This report describes the contract entitled Software Development for Transducer Calibrations. The project was conducted by Pernix Technology for the Transducer Group of the Defence Research Establishment Atlantic (DREA). The contractor upgraded a previously developed system[1] to LabVIEW version 3.1.1 and significantly enhanced system operation.

This section provides an overview of the project requirements and describes the scope and organization of this report. Section 2, "Theory of Operation," describes the system program structure. Section 3, "Problems Encountered," describes the operation of the complete system. Section 4, "Recommendations," identifies future enhancements.

1.2 System Requirements

DREA has two facilities for transducer calibrations: the DREA Barge — Acoustic Calibration Facility on Bedford Basin and the DREA anechoic tank. Using these facilities, several calibration procedures are possible:

(1) Transmitting response using swept sine, pulse or CW.
(2) Receiving response using swept sine, pulse or CW.
(3) Directional response.
(4) Receiving response using pseudo-random noise.
(5) Reciprocity.
(6) Receiving response for an array using swept sine, pulse or CW.
(7) Admittance measurement.
(8) Impedance measurement.

For this contract, Pernix Technology was required to develop the software that controls the equipment to collect the data during the calibration of transducers. The system had to be able to generate tone burst signals or CW signals swept over a frequency band, to measure the voltages seen by the hydrophone, the voltages applied to the projector, and the current flowing through the projector. From these measurements the transmitting response, the receiving response and the admittance and/or impedance of the transducers was to be calculated. The capability to plot the results to a printer and save the data to a disk drive was required.

The developed software is referred to as TRANSCAL. The TRANSCAL software controls the calibration procedure, acquires and processes the received data, and presents the results. The current version of TRANSCAL implements procedures 1 and 2 above. In addition, admittance and impedance measurements are incorporated into procedures 1 and 2.

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[1] See DREA Contractor Report CR/95/411, entitled Acoustic Transducer Calibration Software User's Guide for the LabVIEW 3.1 Environment, written by J. S. Pyra.

2 THEORY OF OPERATION

This section describes the system program structure and the programming and hardware configuration techniques used to implement the system functions. The program structure is described in Section 2.1. The transmitting response functions are described in Section 2.2, and its LabVIEW program implementation in Section 2.3. The receiving response functions are described in Section 2.4, and its LabVIEW program implementation in Section 2.5.

2.1 System Program Structure

The set of calibration procedures are combined into one LabVIEW program – *TRANSCAL.* A detailed description of the program and its usage is given in the User Manual. The TRANSCAL startup front panel is shown in Figure 2.1.

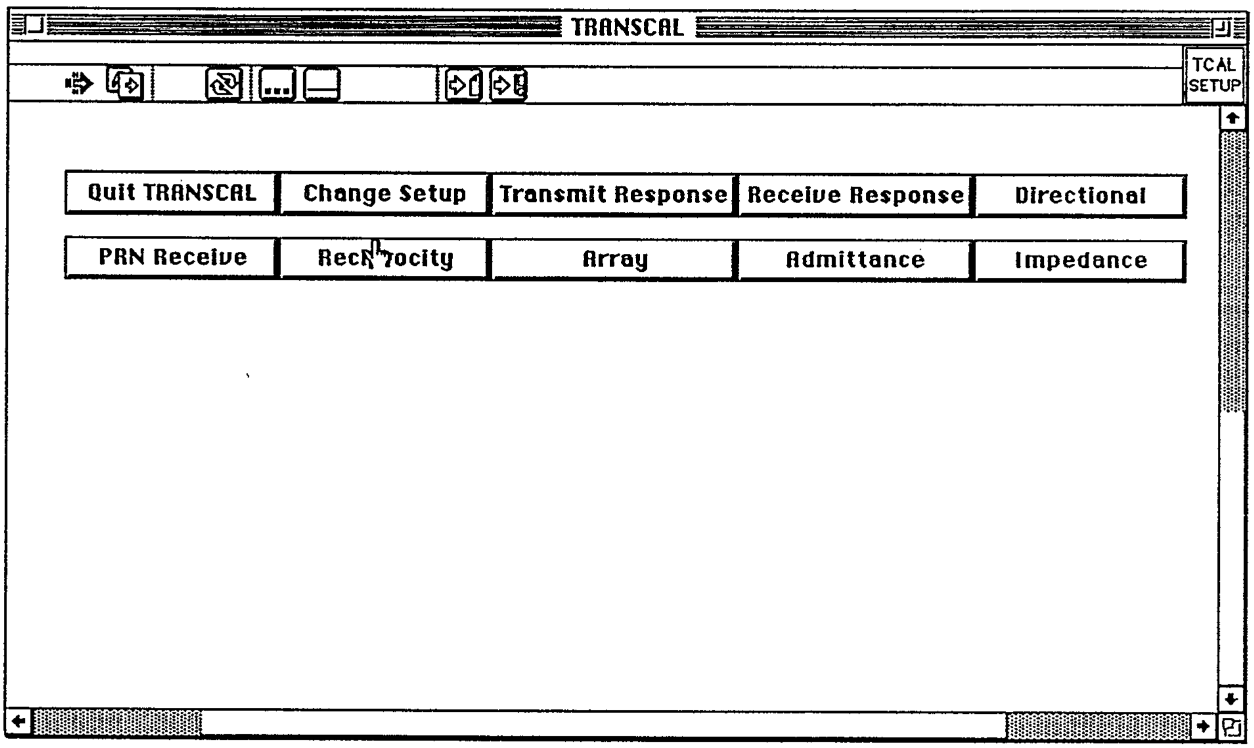

Figure 2.1 TRANSCAL Main Panel.

The program structure is implemented in LabVIEW using a case structure within a while loop. Each of the procedures is contained within a separate case, as shown in Figure 2.2. After system startup, the "initialization" case is executed to reset the system to the default state and to configure the hardware. Each of the calibration procedures is then a separate VI which is executed depending on the user selection of calibration procedure.

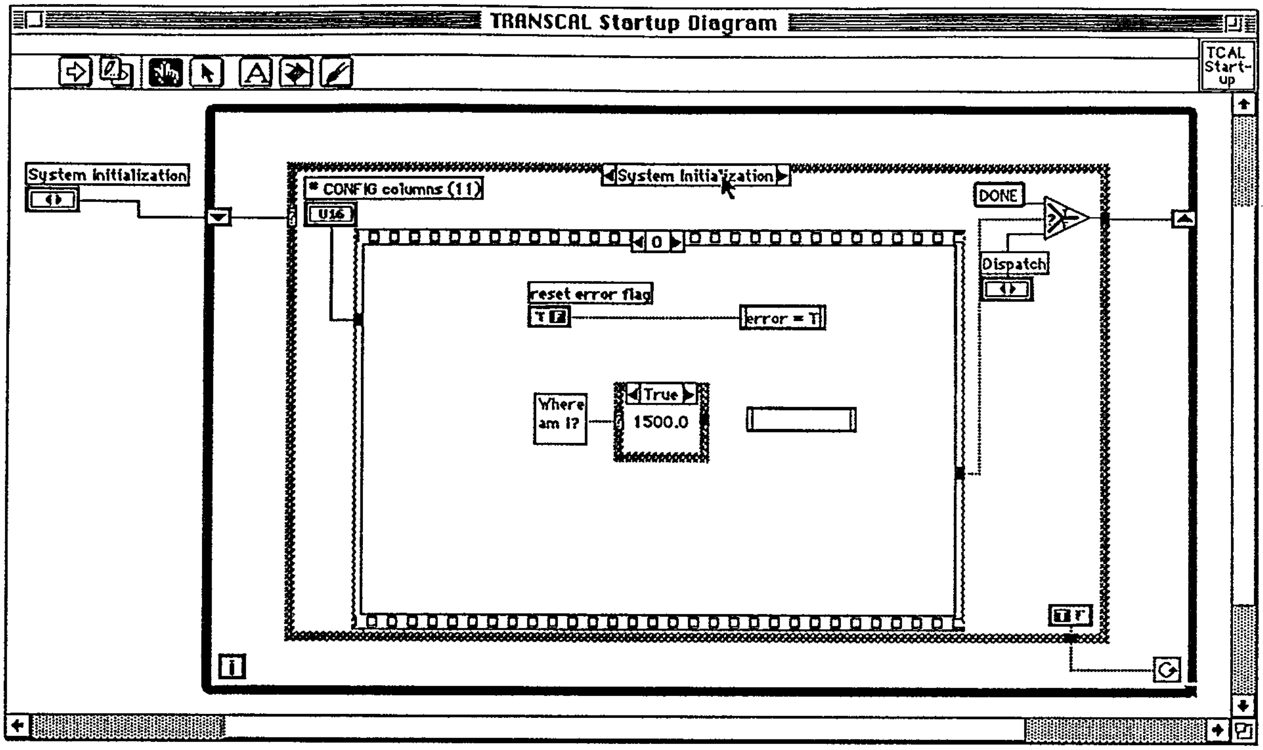

Figure 2.2 System Program Structure LabVIEW Implementation.

2.2 Transmitting Response Functions

Two types of signals are used for transmitting voltage (current) response measurements. The first is a sine wave tone burst signal swept over a frequency band. The second is a sine wave CW signal swept over a frequency range. The user has control over the pulse duration and repetition rate, and sampling delay and duration parameters.

From the voltage applied to the projector, the sensitivity of the hydrophone, the distance between the projector and the hydrophone and the gains of the system the transmitting voltage response is calculated. The transmitting current response is similarly calculated using the projector current. From the applied voltage and current the admittance and/or impedance is calculated.

The user has the option to switch between the transmitting voltage response and the transmitting current response from the same dataset. The admittance can be displayed as real and imaginary parts, or as magnitude and phase information. The impedance can be similarly displayed.

The results can be printed to an attached LaserWriter, mirroring the graph formatting setup by the user on the procedure front panel. The data can also be saved to a data file, which can be read by most spreadsheet, data processing or word processing programs.

2.3 Transmitting Response Implementation

The transmitting response calibration procedure is set up as a state machine diagram structure. Control is passed among the various states depending on the user commands and processing requirements. There are a number of sub-panels which simplify the setup of the various processing parameters, for example to setup the frequency range and projector drive levels.

The main diagram is too large to show in its entirety in this report. Figure 2.3 shows the main processing VIs used during the data acquisition phase, and shows the type of function partitioning typical of the developed programs.

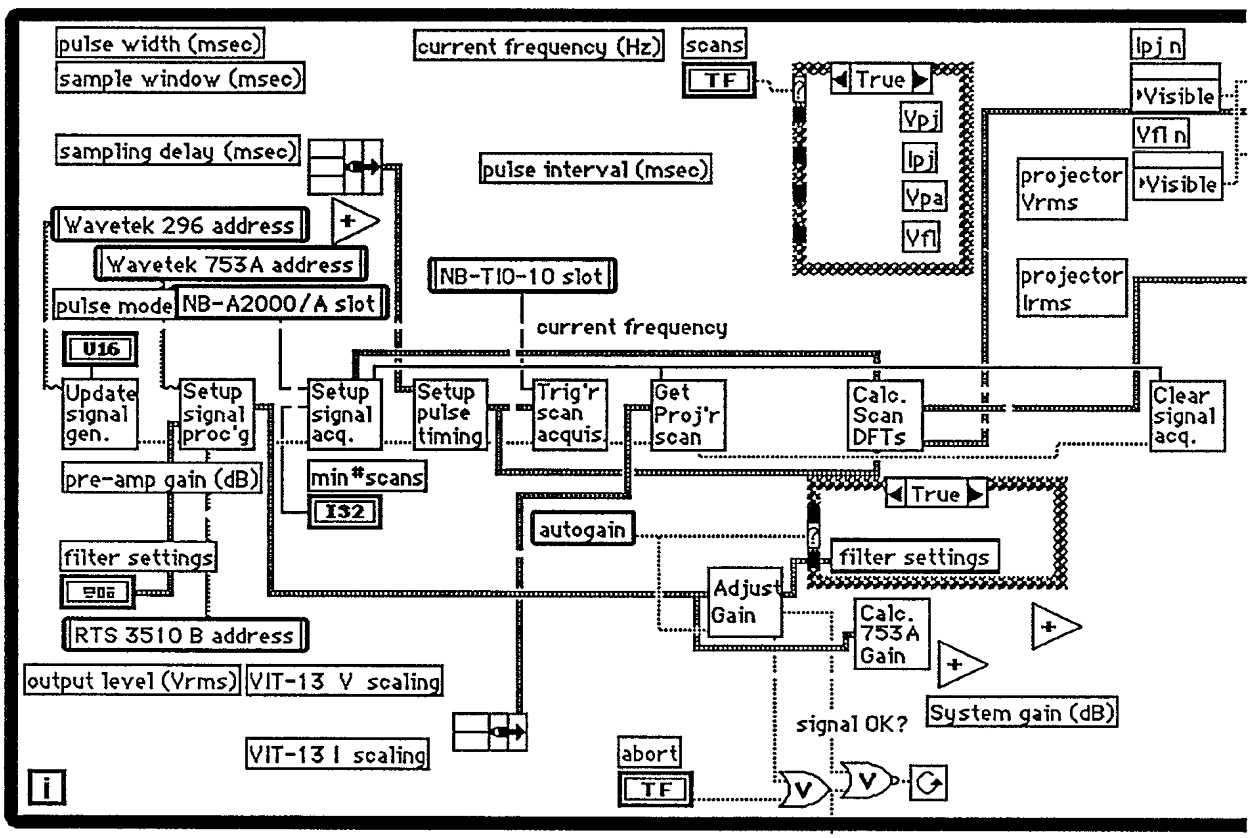

Figure 2.3 Transmitting Response Mode Main Processing VIs

2.4 Receiving Response Functions

The signal generation for receiving response mode is identical to that of transmitting response mode. From the sensitivity of the standard hydrophone, the distance between the projector and the hydrophone and the gains of the system the receiving response is calculated. From the applied voltage and current the admittance and/or impedance is calculated.

The admittance can be displayed as real and imaginary parts, or as magnitude and phase information, as for transmitting response mode. The impedance can be similarly displayed. The results can be printed to an attached LaserWriter, mirroring the graph formatting setup by the user on the procedure front panel. The data can also be saved to a data file, which can be read by most spreadsheet, data processing or word processing programs.

The only fundamental operational difference between transmitting response and receiving response modes is that receiving response requires two data acquisition passes. Each of the standard and unknown hydrophones requires a separate calibration pass. These can be done in any order.

2.5 Receiving Response Implementation

Implementation of the receiving response mode is nearly identical to that of transmitting response mode. The same program structure is used, and the only significant structural change is the addition of an extra state to carry out the data acquisition for the unknown hydrophone. The VIs which perform the calibration calculations are naturally different as well.

3 PROBLEMS ENCOUNTERED

Most of the problems encountered were typical of development projects. The pre-amplifier was malfunctioning in remote operation, which took a while to sort out. There was a broken coax conductor in one of the data acquisition channels. There were problems encountered programming the Brickwall filter, related to ensuring the bandpass parameters are carefully managed as the center frequency sweeps through the range.

The one significant problem with the project was that the development was based on the premise the existing code was capable of being upgraded. This turned out not to be the case, and the resulting TRANSCAL application has been developed from scratch. There are several reasons for this, which do not include the typical tendency of a developer to want to start over. Much time was spent trying to understand and re-use the existing code. This was not possible for three reasons.

The code was originally based on LabVIEW 2.1. Although it had been converted to LabVIEW 3, the conversion was done by recompiling the application using the compatibility VIs. This is not a true conversion, and does not take advantage of the new features of LabVIEW 3. To continue this process would handicap the continued development. TRANCAL has been designed from scratch to use the full capability of LabVIEW 3.1.

The second reason was that the existing applications were poorly designed, and would be nearly impossible to maintain and enhance. Code functions were poorly structured, global variables were overused and misused, and functional partitioning and naming conventions were confusing or non-existent.

The third reason was the programs which were to form the basis of the new programs did not work. Partly because of the need to start over, and partly because of problems experienced by the contractor on other projects, the project was significantly behind the planned schedule.

4 RECOMMENDATIONS

This report has summarized the research contract entitled Software Development for Transducer Calibrations. The system should be a very effective and useful application for transducer calibration. In particular, the operator has flexibility in setting parameters and observing the calibration progress and quality. Program features have been included beyond the requirements to take advantage of the graphical interface and data presentation features of LabVIEW.

Future improvement would include incorporation of an additional NB-A2000, which would double the frequency range capability of the system. The system is presently constrained to 99 kHz by the Brickwall filter. The data acquisition capability is 250 kHz sampling rate, which could be doubled with the addition of a second data acquisition board. Accuracy would be improved at the higher frequencies, and the system would have greater flexibility in pulse acquisition.

One desired feature which arose during the development, but which has not been implemented, is the ability to add additional passes for averaging one-at-a-time, instead of having to specify a fixed number of averages at the beginning. There is certain to be additional desirable features identified as the operators gain experience with the new interface.

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