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EVENT TRIGGERED DATA ACQUISITION IN THE ROCK MECHANICS LABORATORY

Robert D. Hardy
Geomechanics Department
Sandia National Laboratories
Albuquerque, New Mexico 87185

MASTER

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Acknowledgements

DATAVG is based on a program written by D. J. Holcomb in 1983.

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1 BACKGROUND

Increasing complexity of experiments coupled with limitations of the previously used computers required improvements in both hardware and software in the Rock Mechanics Laboratories. Increasing numbers of input channels and the need for better graphics could no longer be supplied by DATAVG, an existing software package for data acquisition and display written by D. J. Holcomb in 1983. After researching the market and trying several alternatives, no commercial program was found which met our needs. The previous version of DATAVG had the basic features needed but was tied to obsolete hardware. Memory limitations on the previously used PDP-11 made it impractical to upgrade the software further. With the advances in IBM compatible computers it is now desirable to use them as data recording platforms.

With this information in mind, it was decided to write a new version of DATAVG which would take advantage of newer hardware. The new version had to support multiple graphic display windows and increased channel counts. It also had to be easier to use.

2 OVERVIEW and DEFINITIONS

This document describes a new and greatly expanded version of DATAVG as used to record data in the Rock Mechanics Laboratory at Sandia National Laboratories/New Mexico. DATAVG is currently at Version 1.10.

DATAVG is an event triggered data logging program. *An event is defined as a change in the quantity measured at any input channel which exceeds a user defined threshold. The triggering threshold, DELTA, is the absolute value of the data change since the last recorded reading.* Input channels are continuously scanned. When a specified change in value has been met at any channel, the data from all channels is recorded in a file and plotted on the video screen.

Allowing any input to trigger recording facilitates tests in which there are several phases. During each phase of the test a different set of input parameters may be of interest. With DATAVG, data recording may proceed without user intervention to change sampling rates, etc.

Event triggering also minimizes the amount of data recorded. With many commercial programs sampling is at uniform time intervals. If a test is to run for a long time but some part of the test requires fast sampling, as near failure of a specimen, a large amount of nearly useless data is recorded. DATAVG avoids this excess data by triggering at long time intervals but short intervals in some other variable.

For instance, the load on a sample may be varied in a series of steps. At each step some process is to be performed. With DATAVG the changes in load will trigger recording during the load change phase. During the other process the load will be constant but some other variable will trigger recording. If nothing else is changing, the time channel will cause some minimal recording rate. See section 7.3 for further information on triggering at time intervals.

DATAVG supports one to four windows for data plotting and emulates an X-Y plotter. Strip chart style plots are not supported. Each window displays data from two channels. The same channel may be displayed in more than one window if needed.

3 OPERATION

DATAVG is menu-driven with the menus arranged in approximately the order required to operate the program as shown below.

- 1) SET UP CHANNELS
- 2) SET UP SCREEN
- 3) PRINT CHANNEL DATA
- 4) CHECK CHANNEL SETUP
- 5) SAVE SETUP DATA
- 6) NAME DATA FILE
- 7) GATHER DATA
- 8) RECALL SETUP DATA
- 9) EXIT TO DOS

Item three, Print Channel Data, is for user convenience and compatibility with the old version. It is convenient for test documentation. Item six, Name Data File, was carried over from the previous version. The Gather Data operation, item seven, will request the file name if it was not defined by item six.

If the setup has been saved in a disk file it may be recalled by item eight. This will eliminate any need for additional setup if a test is to be repeated. The channel and screen data are saved in a form which allows operation immediately after recall. By use of this feature a repeat test may be run by selecting menu item eight followed by menu item seven.

Saved setup files may be recalled then edited by using menu items one or two. It is possible to edit the screen display during a test then save the changes by selecting menu item five before leaving DATAVG. If saving a setup after the data recording runs, first check the First Point Zero flag by using the Channel Setup menu operation. If the first reading happened to be zero, this flag would be altered.

Menu items six and seven ask for a file name to be used for data storage. Two file names are created by appending extensions to the name supplied by the user. The first is "filename.HDR" which stores the program version, a copy of the setup information, a time stamp, column headings and the offsets which are subtracted from subsequent readings. The second file is "filename.DAT" which contains all data for the test. The ".DAT" file is closed and reopened at selected intervals for data security reasons.

Menu operations will now be discussed in order.

3.1 Set Up Channels

In the channel set up routine, most requested values show a default in parentheses immediately before the prompt "?". If this value is satisfactory it may be selected by a carriage return alone.

3.1.1 Test Identification

The first question asked is the test identification. The current test identification is shown and may be changed by entering a new identification. If the current identification is correct, as when editing a set up, just press ENTER.

3.1.2 Channel Selection

Channel set up requests information on the data to be recorded in logical channel order starting with the channel next higher than the highest one previously selected. Channels may be defined in any order by entering the number of the desired channel.

Channel zero (0) is always TIME. TIME is always recorded in seconds starting at the beginning of the test. A prompt will ask for the maximum interval between recordings. This interval is used to trigger recording if other channels are changing slowly.

3.1.3 Channel Name

The user is asked for the name to be used with this channel. The currently assigned name is the default which may be retained by pressing ENTER. The channel name is used for the column heading in the data file and axis labels on plots. Measurement units may be included in the channel name, for example:

LOAD (Kn) or STROKE(in.).

3.1.4 Channel Scale Factor

The next prompt is for units per Volt. This is the real quantity corresponding to +1 volt input. For example, a load cell conditioner provides 5V at 25000 lbs. tensile load. When DATAVG asks for the units per Volt value respond with 5000 lbs. (or 5 KIPS where 1 KIP = 1000 lbs). If compression is to be positive load, enter -5000 lbs. or -5 KIPS. *The units are not entered but are shown here for clarity.* With this information DATAVG can scale readings into proper engineering units.

The calibration plotting software used in the Rock Mechanics Lab provides units per Volt in the graph header.

3.1.5 Trigger Value

The third prompt asks for the input change, in real units, required before recording data is initiated. While recording data, DATAVG continuously scans all input channels. The current readings are compared to the last readings in the data file. When the change equals or exceeds the value entered here the current readings will be recorded in the file and all plots are updated.

3.1.6 Data Offset Removal

The fourth prompt asks if the first data point is to be used as the zero offset. Frequently transducer outputs are not exactly zero at the start of a test. If you are only interested in the change during a test answer this question by pressing ENTER. If true readings are required, answer by pressing "N". Data offsetting is done by subtracting the first readings of a test from all subsequent readings. The offset values are recorded in the data header file so true readings may be restored if this is later required.

3.1.7 Interface Hardware for this Channel

Next the hardware to be used is specified. The user is asked for the interface board in the Keithley box and the channel to be used. The prompt includes a menu of available

boards. Select the board by number from the menu. The menu item numbers correspond to the slot numbers in the Keithley 500 box. Item numbers higher than ten are computed channel pseudo boards. Entries with no corresponding board name will be rejected. After selecting a board, the user is asked for the channel on that board to be used. This prompt includes the valid range of channel numbers and only valid channels will be accepted. The default is the channel following the last one selected on this board.

There is a possibility for confusion in selecting hardware channel numbers. The interface boards use a zero based numbering system. *Each* board starts numbering at zero. DATAVG uses logical channels starting at zero also, but they do not start over on each board. The user must plan hardware usage and be careful to enter proper data.

If the "TEMP" board is selected, a prompt will ask for the thermocouple type. This allows an appropriate conversion to be applied to get degrees Celsius from each reading taken. If there is no AIM7 board or if THERMO.CFG is missing, temperature readings may not be made.

3.1.8 Completion of Channel Set Up

After answering all questions about a channel, DATAVG returns to step 3.1.2. After all channels have been defined, enter "DONE" for the channel number.

Channel setup information will be displayed on the screen in tabular form. Channel zero, if defined, will show a units/Volt value of 1. This is normal and will in no way limit the recording time for a test. It only reflects a scale factor of one which is applied to time readings.

Press enter to return to the main menu.

3.2 Set Up Screen

3.2.1 Number of Windows

DATAVG will display the number of windows currently defined then ask for the number of windows needed. The options are one through four. Invalid responses will be rejected.

During initial setup there are no windows defined and most defaults will be zero. The default X axis channel will be -1 indicating an unused window.

3.2.2 Which Window

After selecting the number of windows, a prompt will ask which window to set up. The default window will start at one and step to the next higher numbered window each time through. Any valid window may be selected instead of the default by entering it's number. Information about the data to be plotted in that window will be requested. This operation repeats until all windows have been set up. If a window is selected which is already configured properly, just take the default values at each question.

First, the user is asked for the number of the channel to be plotted on the X axis then the number of the channel to be plotted on the Y axis. The defaults are the currently defined channels. The first time a window is set up the X axis default will be -1 and the Y axis channel will be zero.

If -1 is entered for the X axis channel, this window will be blank when data recording starts. Blank windows may be activated during a test by redefining them with a real channel on the X axis.

Next, the user will be asked in turn for the minimum and maximum data values to plot on each axis. Default values will be displayed and they may be accepted by pressing ENTER. During initial setup the defaults will be zero. The minimum value plotted must be smaller than the maximum. If the maximum value entered is smaller than the minimum value, DATAVG will exchange them so the plot routine will be happy.

After configuring the last window, a prompt will ask if all windows are properly configured. Press Y to end, or any other key to go back and redo one or more windows. This function may be terminated at any time by entering -1 for the window number.

3.3 Print Channel Data

Selecting this option prints a table of information about this setup. Data is shown in channel number order with only active channels displayed. The table shows the number and name of each channel. This is followed by the full scale value and trigger threshold (DELTA). Last is a zero offset column. If the zero offset value is non-zero, the first reading will be subtracted from all recorded data. Usually the zero offset is one or zero, but it may have any value.

Channel zero, if defined, will show a full scale value of 10. This is normal and will in no way limit the recording time for a test. It only reflects a scale factor of one which is applied to time readings.

Output will be sent to PRN: which may be redirected as needed. After printing the chart, the main menu will be displayed.

3.4 Check Channel Set Up

This operation steps through the channels starting with channel one and displays readings in volts. No scaling is performed. This allows confirmation of readings with a voltmeter. After the reading is shown, the user is asked to change something affecting the channel then press return. A new value will be displayed for confirmation of the change. Pressing return will step to the next channel.

If the letter "A" is entered before the return, the same channel will be displayed again. A channel may be tested as often as needed before going to the next channel.

After all channels have been tested, DATAVG will return to the main menu.

3.5 Save Setup Data

This operation saves all setup information in a file. The configuration of all channels and windows is saved in an ASCII file. A name must be provided for the setup file. An *existing file* of the same name *will be replaced*. There is no check for or warning before replacing an old file.

After creating the setup file the main menu will be displayed.

3.6 Name Data File

As stated above, this operation is not required. It was retained from the previous version of DATAVG because some users like to see a specific way to name their data file. If this operation is not done explicitly before beginning a test, it will be done automatically.

This operation asks for a file name to be used for data storage. Blank lines are ignored until a name is entered. After a name has been entered it is scanned for characters DOS does not like. These are removed so the file name will be valid. If a complete path is specified, the directory must exist. DATAVG will not create directories. Since DATAVG supplies the file type fields, only characters preceding the dot are kept.

After entering a file name, a prompt asks for the number of data points to be stored before closing and reopening the file. A positive number must be entered. Entering one will force closing of the data file after every point is recorded.

If the test will run unattended for long periods, a small number might be used since data probably will not be recorded very fast. Larger numbers of points per file will increase speed if data will be recorded quickly.

After answering these questions, DATAVG will return to the main menu.

3.7 Gather Data

This operation starts data recording. If a data file name has not been specified, this information will be requested as described in Section 3.6.

The first operation is to open the data header file using the name requested above. The header file name is made by appending ".HDR" to the base file name. This header file is described in Section 5.2. The file is opened in append mode to eliminate loss of any previous file of the same name.

Next, all channels will be read and the zero offsets stored in the header file. These data are, also, subtracted from readings taken during the test to remove initial offsets.

The header file is then closed and a new file is opened with the same base name but the type field will be ".DAT". The data file is described in Section 5.3. This file is also opened in append mode and will start with the first data set.

Finally the screen plots are set up. All plots are initialized to display the data ranges specified in Section 3.2. If a window includes a data value of (0,0) in its active area there will be a small cross drawn to mark that location. The cross may be partial if one axis is near zero.

There is a menu across the bottom of the screen. This menu describes the function key actions. If the screen is EGA or better, the menu is two lines with the function key name above it's action. On CGA screens only the function key actions are displayed.

At this time, the program enters a loop. Data is read and compared to the threshold values. If any channel value has crossed the threshold, data from all channels will be recorded and plotted. This loop is repeated until an active function key, as described below, is pressed.

During data recording, there are nine function keys active. Six of them affect windows, and the rest perform various other tasks. Five of the function keys which affect windows perform their task immediately if only one window is active. When multiple windows are active, the user is prompted for the window number.

3.7.1 Force Recording of a Sample (F1)

This function forces recording of a data point. The current reading is stored regardless of threshold crossing.

NOTE:

The following operations are useful but they do cause data logging to stop until the operation is complete. It is recommended that the user be careful in selecting appropriate times to perform these operations to minimize the loss of data.

3.7.2 Reset a Window (F2)

This function resets a window to show the maximum data range on both axes. This is useful if the active plot region cannot be seen. If only one window is defined this function is immediate.

3.7.3 Zoom a Window In (F3)

This function scales the selected window to show a smaller area and centers the plot on the last data point. Both axes are scaled to 75% of their previous length. If only one window is defined this function is immediate.

3.7.4 Zoom a Window Out (F4)

This function scales the selected window to show a larger area and centers the plot on the last data point. Both axes are scaled to 133% of their previous length. If only one window is defined this function is immediate.

3.7.5 Redefine a Window (F5)

This function allows redefinition of a window. The user will be asked for the window number to be redefined. Channels to be plotted and scaling on either axis may be changed. A window may be turned off by assigning channel -1 to the X-Axis. The information required is as described in Section 3.2.2 which describes the screen set up process. After entering the required data, the screen will be restored with the last one thousand data points replotted. If only one window is defined this function is immediate.

This function cannot change the number of windows allocated screen space. For example, if DATAVG was configured to use four windows, screen space is allocated in quarters. If only three windows are in use, this function can turn on the fourth window and it can turn off other windows but it cannot change the size of these windows. If DATAVG is configured to use three windows, the screen is divided into quarters as above. However, this operation cannot turn on the fourth window.

3.7.6 Clear a Window (F6)

This function clears all data from a specified window. A prompt will ask which window to clear. The valid range is displayed and inactive windows are rejected. This option is useful when data is of a cyclic nature and you need to see better detail of a given cycle. A

window is redrawn but no data is plotted. If only one window is defined this function is immediate.

3.7.7 Clear all Windows (F7)

This function clears data from all windows. All windows are redrawn but contain no data traces.

3.7.8 Start a new Data File (F8)

This option closes the current data file and starts a new one with a new name. A prompt will ask for a file name and number of points as described above. No ".HDR" file is created. This is an extension of the test so the previous ".HDR" file is valid.

3.7.9 End the Test (F9)

This function ends the test after confirmation from the user. The user must enter the letter "Y" to end the test. All other responses will cause the test to resume. Data recording is stopped while waiting for the user confirmation.

No shifted or otherwise modified function keys are defined and any unused function keys are ignored.

3.8 Recall Setup Data

This operation asks for the name of a file containing setup data. A valid file name is required. If the name cannot be remembered, press the ESC key and DATAVG will return to the main menu. Exit from DATAVG and find the required name. After opening the file, setup information is read into internal data structures. DATAVG will tolerate setup files which are either too long or too short. A long file will be read until the maximum number of channels have been processed. A short file will leave channels undefined but available for use. The main menu is displayed on completion of this operation.

3.9 Exit to DOS

This operation returns to DOS after files are closed and the screen is cleared.

4 TEMPERATURE CHANNELS

Temperature channels are implemented as computed channels on a pseudo board named TEMP. This board *requires* the presence of an AIM7 interface board. Types J and K thermocouples are supported over a temperature range of -100 to $+500$ degrees Celsius using the tables supplied. The tables may be extended as needed by using the procedure in Section 5.4. The conversion from voltage to temperature is done by a cubic spline interpolation. Interpolation tables are loaded from a disk file (THERMO.CFG) when the first channel of this board is configured. If this file is not present in the current directory DATAVG will issue a message and temperature readings will not be allowed.

5 DISK FILES

5.1 Setup File

Setup files contain all data needed to configure DATAVG for a particular job. Each field in the file will be described in this section. See Figure 1 for an example setup file.

```
LVDT 814 CAL
2
1
0, 0, 0, , 0, , , 0
0.01007, 0.0005, 1, AMM2, 1, I, 0.1" STANDARD, 1
1, 10, 1, AMM2, 2, I, LVDT 814, 2
0, 0, 0, , 0, I, , 0
0, 0, 0, , 0, I, , 0
0, 0, 0, , 0, I, , 0
...
0, 0, 0, , 0, I, , 0
0, 0, 0, , 0, I, , 0
0, 0, 0, , 0, I, , 0
1, 2, 0, 100, 5, 100, -0.01, 0.01, -10, 10
-1, 0, 0, 0, 0, 0, 0, 0, 0, 0
-1, 0, 0, 0, 0, 0, 0, 0, 0, 0
-1, 0, 0, 0, 0, 0, 0, 0, 0, 0
```

Figure 1: Setup File

The first line lists the test name. The second line contains the highest numbered active channel plus one and the third line contains the number of active windows.

Subsequent lines contain data for each channel. All available channels are represented whether they are used or not.

Data are as follows with the fields separated by commas and spaces.

Column one, Scale factor in units per volt. *Column two*, Trigger threshold in scaled units. *Column three*, Flag indicating whether the first reading is to be the zero offset. Non zero values indicate a zero offset will be applied. *Column four*, The interface board name. *Column five*, The hardware channel number on this board. *Column six*, A channel type character (I (in), O (out) or C (computed)). *Column seven*, The channel name. *Column eight*, The column number these data will occupy in the output file (0 if not in the file).

The last four lines contain data about the windows. This data is the screen positions and user unit ranges for both axes. The data is as follows with the fields separated by commas and spaces.

Column one, X axis channel. *Column two*, Y axis channel. *Column three*, Screen X axis minimum. *Column four*, Screen X axis maximum. *Column five*, Screen Y axis minimum. *Column six*, Screen Y axis maximum. *Column seven*, User unit X axis minimum. *Column*

eight, User unit X axis maximum. *Column nine*, User unit Y axis minimum. *Column ten*, User unit Y axis maximum.

5.2 Header File

The header file (filename.HDR, Figure 2) starts with the version of DATAVG being used. The version includes the compilation date. The version information occupies the first two lines. Next comes a copy of the setup data as described in Section 5.1. There is a time stamp (including the date and time) followed by the column headings. Column headings are the names of each active channel. The offset data are stored in the last line of the header file. This offset information may be used to reconstruct actual readings if needed.

```
DATAVG FOR THE IBM PC
Version 1.0, 5/12/1992
LVDT 814 CAL
2
1
0, 0, 0, , 0, , , 0
0.01007, 0.0005, 1, AMM2, 1, I, 0.1" STANDARD, 1
1, 10, 1, AMM2, 2, I, LVDT 814, 2
0, 0, 0, , 0, I, , 0
0, 0, 0, , 0, I, , 0
0, 0, 0, , 0, I, , 0
...
0, 0, 0, , 0, I, , 0
0, 0, 0, , 0, I, , 0
0, 0, 0, , 0, I, , 0
1, 2, 0, 100, 5, 100, -0.01, 0.01, -10, 10
-1, 0, 0, 0, 0, 0, 0, 0, 0, 0
-1, 0, 0, 0, 0, 0, 0, 0, 0, 0
-1, 0, 0, 0, 0, 0, 0, 0, 0, 0

Mon Aug 31 15:31:50 1992

" 0.1" STANDARD" " LVDT 814"
-0.999594, -0.93985
```

Figure 2: Header File

If a filename is re-used, the new header information will be appended to the existing file. It is easy to find the new header information by searching for the DATAVG program name in the file.

5.3 Data File

Data storage starts in the second file (filename.DAT, Figure 3). Data are stored in ASCII real numbers with commas and spaces between columns. The data format may be floating point or exponential, whichever is shorter. Time data is expressed in elapsed seconds, since the start of test, in floating point format. All data from an event are stored in a single line. Lines are terminated by CR LF pairs as is customary in DOS systems.

```
-6.46163e-06, -0.00256348
-0.00056577, 0.55899
-0.00107591, 1.04019
-0.00158082, 1.55411
...
-0.0057996, 5.76239
-0.00634324, 6.29132
-0.00687273, 6.83188
```

Figure 3: Data File

Data files (filename.DAT) contain data only. If a filename is re-used, data will be appended to the existing file. There is no blank line or other marker in the file to indicate where re-use started. It is possible to find the point where data was appended by looking for a jump, usually negative, in the time channel.

5.4 Thermocouple Data Tables

The tables in THERMO.CFG are created by a supporting program (BUILDTTC, see Appendix G for source code), and are based on tables in the OMEGA temperature measurement data book Vol. 28. Tables may be created or extended by creating a file named TEMP.D containing temperature, millivolt pairs in ascending order of temperature.

In THERMO.CFG, the first line of a table must contain the thermocouple type letter, a comma and the number of temperature points in the list. Subsequent lines contain the AIM7 board output in volts referenced to zero degrees C, a comma then the temperature in degrees Celsius, a comma and the cubic spline coefficient data. One data point is allowed on a line. Multiple thermocouple types may be contained in a file by concatenating them. *While BUILDTTC does not care how many types are contained in a file, only the first ten will be read by DATAVG.* To conserve memory, the number of types should be kept to a minimum and only the types in use should be in the configuration file THERMO.CFG.

6 INSTALLATION NOTES

When installing DATAVG, a file named K500.CFG, Figure 4, must be created. It must contain the address of the interface board and the names, etc., of the boards in the Keithley box. This file is described in detail in Section 6.1.

The first line contains the segment address of the 500-IBIN-A interface board. This board is memory mapped and *must* not conflict with other boards or DOS. If DOS 5.X or Windows is in use, it is possible to load system programs in high memory areas which may conflict with the factory default address of CFF8 HEX. Run the DOS command

MEM /D > PRN:

to print the memory map. If any programs start at addresses near CFF80, check for conflicts. Any conflicts will require changing the board address, as described in the Keithley manual, to remove the conflict. In a GATEWAY 2000 486DX2/50, setting the board to DFF8 works. *DATAVG has not been tested with EMM386.*

6.1 Keithley Box Configuration File

The file K500.CFG, Figure 4, must be in the \DATAVG directory when DATAVG is started. This file contains the configuration of the Keithley 500 mainframe. K500.CFG *must* be maintained current for the specific computer. This is the only part of DATAVG which is specific to a particular computer.

The first line contains the segment address of the interface board expressed in HEX notation. When DATAVG starts, it reads K500.CFG and uses this address to initialize the interface board. Subsequent lines contain a list of the boards present.

Board list lines contain four fields separated by commas. The first field is the board name. Following the name is the slot number, channel count and board type. The type is Input or Output.

While newer Keithley 500 mainframes can identify the boards present, DATAVG does not currently make use of this feature. Instead, DATAVG uses the board list in K500.CFG.

6.2 Temperature Data Files

The temperature measurement system in DATAVG uses pre-computed data tables which are read from a file named THERMO.CFG. THERMO.CFG must be in the \DATAVG directory when temperature channels are configured. The file structure is discussed in Section 5.4.

```
D0F8
AMM2,1,16,I
AIM3,3,32,I
AOM1,5,2,O
DIO1,8,16,I
DIM1,9,16,I
PIM2,10,4,I
```

Figure 4: Keithley Configuration File, K500.CFG

7 LIMITATIONS AND REQUIREMENTS

DATAVG uses 500LIB to interface with its hardware. The library is written with the assumption that a Keithley 500-IBIN-A interface board is present. This board contains the counters and clock used to time events. The older 500-IBIN board will not work since it does not include a crystal oscillator. The analog input routines assume a sixteen bit A/D converter on a Keithley 500-AMM2 board. If different hardware is needed, 500LIB must be modified and recompiled.

7.1 File Management

Data are recorded whenever the defined threshold is crossed on any channel. Data are written to disk when they are plotted on screen. A power failure during a test could cause the loss of any data written to the file. Closing the file assures that the disk directory will be updated in a timely manner which reduces chances of data loss. Therefore, for data security, the number of data points recorded in a file before closure is limited. When this limit is reached the file is closed and reopened. Subsequent data are appended to the file, and this process is repeated until the end of test. There is a limit of 65536 data points before closing the data file.

7.2 Screen Management

All plots are updated to reflect the latest data written to disk. This update does not wait for the file closure discussed in Section 7.1.

7.3 Time Interval Triggering Limits

The time data used for triggering is stored in a float. This supplies sufficient precision to allow triggering at one-second intervals for about ninety days. If a test runs longer than this, trigger at longer intervals. Actually, one-second intervals would be rather short for a test of this length so the loss of precision should not be a problem.

8 COMPUTED CHANNEL DESIGN

The remainder of this document is primarily of interest to programmers. The user probably will not need to read further. This section is included to document the program structure.

8.1 COMPUTED CHANNEL INTERFACE

Computed channels are implemented using object-oriented programming techniques. They are treated by DATAVG as if they resided on boards. Pseudo boards may be defined which have needed properties. These boards may support multiple channels like a real board. Each channel of a pseudo board must return a computed value based on real readings and/or other computed channels.

The user may write computed channel drivers and link them into the program by making proper references in the MAKEFILE. This requires adherence to the function prototype to

avoid compiler complaints. User-written drivers must take care of any required initialization. User-written drivers must `#include "DATAVG.H"`. If using Borland MAKE, create a file named DATAVG.LNK containing the linker instructions.

Computed channel drivers must keep static variables or arrays containing information used for their calculations. They must, also, handle four functions signified by the `card_slot` variable. `Card_slot` values of `-1`, `-2` and `-3` specify special functions as described below.

Another requirement is to place the function prototype near the beginning of DATAVG.H so the compiler can reference it. Include the board name, slot number, channel count, type and driver pointer in the `box[]` array found in DATAVG.H. When installing the pseudo board, choose a slot number greater than ten and within the limits of the `box[]` array, (currently 15 as defined by `MAX_SLOT`). Board names should be seven or less characters.

8.1.1 Computed Channel Driver Function Prototype

The function prototype for computed channel drivers is:
`float name(int channel, int card_slot, int num_to_ave).`

8.1.2 Initialize Computed Channel

A `card_slot` value of `-1` signifies a need to initialize this channel. This function may request any information required to perform the required operation such as scale factors and input sources.

In the `setup_channels` function (Section 3.1), the user is asked for data about each channel. Part of this data is the board name and board channel to be used for this program channel. If the board is a pseudo board, the board driver will be called to do any required initialization. The initialization request will be signified by a `card_slot` number of `-1`. When making the initialization call, the driver will be given the pseudo board channel to be configured. The `num_to_average` variable will contain the program channel number being processed. The program channel being processed is useful in detecting references to other channels which will contain obsolete data at the time this channel is evaluated. Only channel numbers less than this one can provide currently valid data from the `D[]` array.

Computed channel drivers may use *previous* channel data, or they may make independent readings from the interfaces. During set up, it is possible to test references to other channels to see if they have been defined. This may be done by testing their scale variable (`channels[n].scale`). Channels which are in use have non-zero scale factors. References to undefined channels should be treated as warnings, since they may be defined later. At run time, references to undefined channels should be flagged as errors and the run stopped.

During configuration of a computed channel, a physical channel may be selected by a call to `get_valid_board()`. This function requires a pointer to the prompt text. It returns an index into the `box[]` array where information about the board is located. `get_valid_board()` also returns the selected channel on the board. The driver element of the `box[]` array entry may be called to make a real reading. Several real readings may be taken as needed by calling the appropriate drivers. This data may be combined with data from *previously* read channels as needed. Previously read data is in the `D[]` array and may be indexed by the channel number. Obtaining data from the `D[]` array is much quicker than making new readings. It is possible to write drivers which use new readings only when needed.

8.1.3 Save Computed Channel Set Up Data

The `save_setup()` function (Section 3.5) in DATAVG calls computed channel drivers during its operation. `save_setup()` calls the driver with the pseudo board channel number and a slot number of `-2`. The driver must write any required data to the setup file. This operation is needed because DATAVG has no way to know what this driver does or how it is done. Drivers normally maintain private data which needs to be restored before operation can resume. The file pointer to be used is `data_file` and the information should be saved in ASCII with a newline at the end.

8.1.4 Restore Computed Channel Configuration

The `restore_setup()` function in DATAVG (Section 3.8) calls computed channel drivers during its operation. `restore_setup()` calls the driver with the pseudo board channel number and a slot number of `-3`. The driver must read saved set up data from the setup file, using the file pointer `data_file`, and rebuild its internal tables. User prompts may be made for other data as required.

8.1.5 Normal Computed Channel Operation

During data collection, the driver for a computed channel will receive a `card_slot` number as shown in `channels.card_slot`, the channel number for this board and the number of readings to average. The number to average is a compile-time constant and is probably meaningless in a computed channel context but is included for a consistent interface.

The driver must perform its function and return a float result. If data from lower numbered channels is desired, it may be obtained from the `D[]` array. The channel number is the index into this array.

8.1.6 Support Functions

There are several support functions available to writers of computed channel drivers. These include functions to prompt for and validate numerical data and board identification. Use of these functions can make your code smaller and easier to write.

8.1.6.1 Get an Integer with prompt and default. `get_int()` returns an integer. It requires a prompt string and default value. Input is validated to insure the correct type, and the default is returned if the user presses ENTER alone. See the prototype in DATAVG.H for details of this function.

8.1.6.2 Get a Float with prompt and default. `get_float()` returns a float. It requires a prompt string and default value. Input is validated to insure the correct type, and the default is returned if the user presses ENTER alone. See the prototype in DATAVG.H for details of this function.

8.1.6.3 Get a Board and Channel. `get_valid_board()` requires a pointer to a prompt string. It asks for and obtains a board and channel identification. This function returns an index into the `box[]` array. By using this index, a description of the selected board may be located. This function also returns a channel number on the board. See the prototype in `DATAVG.H` for details of this function.

8.1.6.4 Validate a File Name. `validate_file_name()` requires a pointer to a string containing the file name to be validated. All characters DOS does not like are removed and the remainder are concatenated in the original string. The name and type fields are truncated so they do not exceed their maximum lengths. This function removes control and illegal characters but *does not* case shift the string.

9 PROGRAM STRUCTURE

DATAVG, written in Turbo C for the IBM PC family, is derived from a program of the same name which ran on a Digital PDP-11. The original, written in MTS BASIC, was severely limited by the hardware environment. Using the PC allows greater flexibility in interfacing and display hardware and larger memory.

DATAVG currently operates with a Keithley 500 data acquisition system. A Keithley 500-IBIN-A interface board is *REQUIRED* since it contains the clock circuits used for timing events. A Keithley 500-AMM2 board is assumed, but a 500-AMM1 could be used with minor program changes, as could the Keithley 570 or other hardware.

DATAVG supports computed channels which are implemented using object-oriented programming techniques. Computed channels may perform nearly any function required including experiment control. In this implementation of DATAVG, there is a temperature board which is implemented using computed channels. See Section 8 for instructions on writing your own drivers.

Display hardware which may be used includes IBM CGA, EGA, VGA and IBM8514 color plus Hercules monochrome. EGA, VGA and 8514 are definitely preferred. When using a color interface board, a color monitor *MUST* be used. There is no support for gray scale on a monochrome VGA system.

DATAVG source code is contained in the file `DATAVG.C` (Appendix A for `DATAVG.H`, and Appendix B for `DATAVG.C`). This module requests inclusion of `DATAVG.H` which includes any required standard header files and a few locally-created header files. Locally-created headers are `500LIB.H` and `SRBGRAPH.H`. `DATAVG.H` contains definitions and data declarations for the program. `500LIB.H` and `SRBGRAPH.H` provide function prototypes for their respective modules.

DATAVG uses `500LIB` to interface with the hardware. This is a driver package written in Turbo C which makes some assumptions about the available equipment. This library was not intended to be as comprehensive as the Keithley-supplied driver package. It is assumed that there will be a 500-IBIN-A interface board or equivalent which provides the timing equipment. Further, it is assumed there will be a 500-AMM2 in slot one of a Keithley 500 mainframe. By changing some definitions and recompiling the library, it is possible to support a 500-AMM1. Source code for `500LIB.H` is in Appendix C and `500LIB.C` is in Appendix D.

In writing DATAVG, efforts were made to keep the code modular and to eliminate special cases. Channel zero (TIME) requires some special treatment since no scaling is done. Also, computed channels are “Black Boxes” which may have private data. This requires that computed channel drivers be able to do their own setup. They must, also, be able to save and restore their own configuration.

Functions were written so they could be used in several places throughout the code. Some functions are used to set up the parameters for a call to another, reusable, function. In a few cases, the use of flag variables allowed changing the behavior of functions for initialization vs. normal use.

In user-interface functions where speed is not needed, functions were used to make the code more readable. This was done where the same type of information was requested in several places and verification was needed.

In the user-interactive routines, extensive range checking has been implemented. When input is requested, the data is checked to prevent use of invalid information. For instance, if a number is needed the program will not allow alphabetic entries. Most prompts include acceptable ranges, and these are tested before DATAVG will continue.

Routines which read files created by this program do not contain extensive range testing. It was assumed that data in files created by DATAVG, including setup files, had already been range checked and was correct. While it is possible to modify or create setup files with a text editor, there is virtually no error checking while reading them. Be careful when editing setup files.

DATAVG uses SRBGRAPH to do plotting. This is a graph package written by S. R. Brown and modified by R. D. Hardy (both Sandia National Laboratories). SRBGRAPH is a very modular library of object modules which may be linked into any program which requires X-Y graphing capabilities. See Appendix E for the header SRBGRAPH.H and Appendix F for composite source code.

10 VARIABLES

This section discusses the global variables used by DATAVG.

10.1 Global General Data

```
char BUFFER[64];
```

This is a character array used for data entry from the keyboard. In the functions which interact with the user, most data are read in string form and later parsed into the required form.

```
char Test_ID[64];
```

This string holds the test identification which is placed in the data file header.

```
char Data_file_name[64];
```

This string holds the complete data file path. Space is allowed for the longest path DOS can handle.


```
int num_chan;
```

This is the highest program channel number in use. It is not the number of channels. This variable appears in line two of the setup file.

```
int Points_this_file;
```

The number of data points recorded since opening the data file. This variable is used to decide when we need to close and reopen the data file.

```
int Points_per_file;
```

The number of points to store before closing and reopening the data file.

```
long Total_points;
```

Total number of data readings recorded in this test.

```
int plot_data_count;
```

This variable is not used as its name implies. It is an index into the channel data storage buffer. This variable is used by the plot function and to compare current data against previously stored data.

```
int plot_windows;
```

The highest numbered window in use. This variable appears in line three of the setup file.

```
unsigned int SEQUENCE;
```

A flag used to show whether we are storing data or the data header.

```
float D[MAXCHAN+1];
```

This global array contains the current data readings. During data scanning, this array contains data for all channels which have been read. Higher numbered channel data is not valid. Computed channels may use data from this array as needed.

```
FILE *data_file, *printer;
```

File pointers.

10.2 Time Data

```
struct ktime Ktime;
```

A structure defined in 500LIB.H which is used to return time codes from the Keithley interface board.

```
double base_time;
```

This variable holds the time when data recording started. This value is subtracted from all times to get relative time from the start of recording.

```
double rel_time;
```

This variable holds the time from the Keithley board relative to program start. The Keithley board timer is started during program initialization and can contain a significant value before recording starts.

```
struct timeb start_time;
```

A structure defined in /TC/INCLUDE/SYS/TIMEB.H. This structure is used to return DOS system time which is used to time stamp the data file header.

10.3 Plot Data

```
typedef struct Window
{
    int Xchan;    /* Channels to plot on each axis */
    int Ychan;
    int SXmin;    /* Screen coordinates for this window */
    int SXmax;
    int SYmin;
    int SYmax;
    float UXmin; /* User coordinates for this window */
    float UXmax;
    float UYmin;
    float UYmax;
};
```

This structure defined in DATAVG.H contains all required data about a given window.

```
struct Window win_data[MAXWINDOWS];
```

An array of window data structures with one entry for each window. A maximum of four windows is allowed in the current version, but this could be changed if required. Four windows are a good trade between visibility and the amount of data we could display.

10.4 Program Channel Data

```
typedef struct ch
{
    char name[64];        /* title for axis labels */
    float scale;          /* data scale factor, units per volt */
    float trigger;        /* delta value to trigger recording */
    float zero;           /* zero offset value */
    int card_slot;        /* interface device slot number */
    int chan;             /* interface device channel */
    float (*driver)();    /* Pointer to the driver function */
    char type;           /* channel type, In, Out or Computed */
    float far *data;     /* data buffer pointer */
};
```

This structure defined in DATAVG.H contains the data required for each program channel. It can be used for either real or computed data channels.

```
struct ch channels[MAXCHAN+1];
```

An array of channel data structures. There is one entry for each program channel allowed. Currently there are thirty channels but this could be increased if needed.

10.5 Hardware Information

```
typedef struct k500 /* interface box configuration info */
{
    char board[8];      /* board name */
    int card_slot;      /* slot in box */
    int channels;       /* number of channels supported */
    char type;          /* input or output (I, O or T) */
    float (*driver)();  /* Pointer to the driver function */
};
```

The box[] array of structures defined in DATAVG.H contains data for each Keithley 500 board present. This structure is also used to hold information about pseudo boards supporting computed channels starting at card_slot 11. There is an entry for each real and pseudo board. Currently there are fifteen entries, but this could be changed.

```
struct k500 box[MAX_SLOT + 1];
```

The boards data structure defined in DATAVG.H contains a master list of all Keithley boards and their characteristics. It is used during auto-identify and to hold driver pointers. Limited to 35 boards by hardware limitations. This array of structures is initialized at compile time.

```

struct module
{
    char name[8];
    int channels;
    char type;
    float (*driver)();
};

struct module boards[MAX_BOARDS];

```

10.6 Other Variables

There are local variables used in various functions. The variables i, j, k and n are frequently used for loop counters and indexes. Other variables are named and commented so their function is obvious.

END OF VARIABLES LIST

APPENDICES

A DATAVG.H

```
/* ***** */
/* datavg.h */
/* Header file for DATAVG data logging program. */
/* Written by */
/* R. D. Hardy */
/* Sandia National Laboratories */
/* Department 6117 */
/* April 17, 1992 */
/* */
/* Modification History */
/* */
/* June 25, 1993 */
/* Changed definition of SIXTEEN RDH */
/* */
/* Comments configured for C2LATEX and LATEX */
/* ***** */

#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <time.h>
#include <sys\timeb.h>
#include <conio.h>
#include <math.h>
#include <ctype.h>
#include <dos.h>
#include <spline.h>
#include "500lib.h"

#ifdef DATAVG
#include <graphics.h>
#include <srbgraph.h>
#define VERNUM 1.10 /* Version Number */
#endif

/* MAXCHAN = MAXIMUM NUMBER OF LOGICAL CHANNELS EXCLUDING TIME */
#define MAXCHAN 40

/* MAX_SLOT is the number of boards allowed including psudo-boards */
#define MAX_SLOT 15

/* Other constants */
#define MAX_MODULES 35 /* number of entries in boards array */
#define MS_COUNT ((unsigned int)1000) /* counter 1 value, one second */
#define SEC_COUNT ((unsigned int)1000) /* counter 0 value, seconds counter */
#define Zoom_Scale 0.75 /* Window zoom scale factor */

/* global function prototypes */
void validate_file_name(char *name);
void get_valid_board(char *text, int *box_index, int *chan);
float get_float(char *prompt, float def);
int get_int(char *prompt, int def);
float (*find_driver_pointer(char *name))();
char *get_board_name(float (*driver)());
```

```

/* computed channel prototypes */
float axial_stress(int chan, int card_slot, int n);
float thermocouple(int chan, int card_slot, int n);

/* ***** */
/* global data */
#ifdef MAIN
#define EXTERN
#else
#define EXTERN extern
#endif

EXTERN float D[MAXCHAN+1]; /* input data buffer */
EXTERN char board_list[300]; /* List of available boards */

typedef struct ch /* Channel data */
{
    char name[64]; /* title for axis labels */
    float scale; /* data scale factor, units per volt */
    float trigger; /* delta value to trigger recording */
    float zero; /* zero offset value */
    int card_slot; /* interface device slot number */
    int chan; /* interface device channel within slot */
    float (*driver)(int chan, int card_slot, int n);
    char type; /* channel type, (Input, Output, Computed) */
    float far *data; /* data buffer pointer */
};

EXTERN struct ch channels[MAXCHAN+1]; /* MAXCHAN channels plus TIME */

typedef struct k500 /* interface box configuration info */
{
    char board[8]; /* board name */
    int card_slot; /* slot in box */
    int channels; /* number of channels supported */
    int last_chan; /* last channel used on this board */
    char type; /* input or output (I, O or C) */
    float (*driver)(int chan, int card_slot, int n);
};

#ifdef MAIN

    struct k500 box[MAX_SLOT + 1] =
    {
        /* Card slot zero is not used, it is a dummy only */
        /* this space will be filled in during program startup */
        {"",0,0,-1,' ',NULL}, /* dummies for real card slots */
        {"",1,0,-1,' ',NULL},
        {"",2,0,-1,' ',NULL},
        {"",3,0,-1,' ',NULL},
        {"",4,0,-1,' ',NULL},
        {"",5,0,-1,' ',NULL},
        {"",6,0,-1,' ',NULL},
        {"",7,0,-1,' ',NULL},
        {"",8,0,-1,' ',NULL},
        {"",8,0,-1,' ',NULL},
        {"",10,0,-1,' ',NULL},
    }

```

```

/* Install computed channel data starting here */
/* Make sure MAX_SLOT is large enough to include all entries */

    {"TEMP",11,16,-1,'C',thermocouple},
/* "AXSTRES",12,1,-1,'C',axial_stress This module not tested */
};

#else
    extern struct k500 box[MAX_SLOT + 1];
#endif /* MAIN */

EXTERN FILE *data_file;

#ifdef DATAVG
#ifdef MAXWINDOWS > 4
    #undef MAXWINDOWS
    #define MAXWINDOWS 4 /* we use only four windows */
#endif /* MAXWINDOWS */

/* data buffer size */
#define BUFSIZE 1000

/* number of readings to average for noise reduction */
#define Num_to_average 10

/* window position definitions in percent of full screen */
#define WIN_TOP 100

EXTERN int WIN_BOTTOM;
#define WIN_LEFT 0
#define WIN_RIGHT 100

/* menu bar position definitions in percent of full screen */
EXTERN int MENU_TOP;
#define MENU_BOTTOM 0
#define MENU_LEFT 0
#define MENU_RIGHT 100

EXTERN double base_time; /* time offset, holds starting time */
EXTERN double rel_time; /* time from start of program */
EXTERN int plot_data_count; /* counter for points in plot buffers */
EXTERN long Total_points; /* total points recorded in test */
EXTERN int Points_this_file, Points_per_file;
EXTERN int Check;
EXTERN int num_chan;
EXTERN int plot_windows; /* number of windows to use */
EXTERN unsigned int SEQUENCE;
EXTERN FILE *printer;
EXTERN union REGS Regs; /* register copy for int86() */
EXTERN char Test_ID[64];
EXTERN char Data_file_name[64];
EXTERN char filename[64];
EXTERN char BUFFER[64];

EXTERN struct ktime Ktime; /* time code buffers for KEITHLEY counters */
EXTERN struct timeb start_time; /* wall clock time storage */

```

```

typedef struct Window                                /* our window data */
{
    int Xchan;                                       /* X channel for this window */
    int Ychan;                                       /* Y channel for this window */
    int SXmin;                                       /* Screen coordinates for this window */
    int SXmax;
    int SYmin;
    int SYmax;
    float UXmin;                                    /* User coordinates for this window */
    float UXmax;
    float UYmin;
    float UYmax;
};

```

```

EXTERN struct Window win_data[MAXWINDOWS];

```

```

/* master data structure used during auto-identify and to hold */
/* driver pointers */

```

```

struct module
{
    char name[8];
    int channels;
    char type;
    float (*driver)(/*int chan, int card_slot, int n*/);
};

```

```

#ifdef MAIN
struct module boards[MAX_MODULES] =
{
    {"AMM1A",1,'I',NULL},
    {"AMM1",1,'I',NULL},
    {"AMM2",16,'I',read_AMM2},
    {"AIM2",2,'I',NULL},
    {"AIM3",32,'I',read_AIM3},
    {"AIM4",1,'I',NULL},
    {"AIM5",1,'I',NULL},
    {"AIM6",1,'I',NULL},
    {"AIM7",16,'T',read_AIM7},
    {"AIM8",1,'I',NULL},
    {"AIM9",1,'I',NULL},
    {"PIM1",2,'I',NULL},
    {"PIM2",4,'I',read_PIM2},
    {"STEP1",1,'O',NULL},
    {"STEP2",1,'O',NULL},
    {"AOM1/2",2,'O',write_AOM1},
    {"AOM1/5",5,'O',write_AOM1},
    {"AIM2/1",1,'I',NULL},
    {"AOM2/2",2,'O',NULL},
    {"AOM3",2,'O',NULL},
    {"AOM4",2,'O',NULL},
    {"DIM1",16,'I',read_DIM1},
    {"DOM1",16,'O',NULL},
    {"DIO1",16,'O',write_DIO1},

```



```

{"PCM1",1,'O',NULL},
{"PCM2",2,'O',NULL},
{"GPIB",1,'I',NULL},
{"PROTO",1,'O',NULL},
{"",1,'I',NULL},
{"",1,'I',NULL},
{"",1,'I',NULL},
{"",1,'I',NULL},
{"",1,'I',NULL},
{"",1,'I',NULL},
{"",1,'I',NULL},
{"",1,'I',NULL},
};

#else
extern struct module boards[MAX_MODULES];
#endif /* MAIN */
#endif /* DATAVG */

#undef EXTERN

```

B DATAVG.C

```
/* ***** */
/* DATAVG.C ** DATAVG FOR THE IBM PC FAMILY. */
/* USES ALL INPUT BOARDS SUPPORTED BY A KEITHLEY 500 BOX. */
/* THE FILE K500.CFG MUST BE PRESENT IN THE DATAVG DIRECTORY TO */
/* INFORM THIS PROGRAM ABOUT AVAILABLE HARDWARE. */
/* THE FILE THERMO.CFG MUST BE PRESENT IN THE DATAVG DIRECTORY TO */
/* PROVIDE THIS PROGRAM WITH THERMOCOUPLE CURVE DATA. */
/* MAXCHAN IS THE NUMBER OF CHANNELS SUPPORTED BY THIS PROGRAM */
/* EXCLUDING TIME. BUFSIZE IS THE DATA BUFFER SIZE FOR EACH CHANNEL */
/* */
/* Written by: */
/* R. D. Hardy */
/* Sandia National Laboratories */
/* Department 6117 */
/* April 17, 1992 */
/* */
/* Comments configured for C2LATEX and LATEX */
/* ***** */
/* Modification History */
/* */
/* June 25, 1993 */
/* Changed get_setup() so it will read setup files created with more */
/* or less than MAXCHAN channels. RDH */
/* */
/* */
/* */
/* */
/* */
/* ***** */
/* MODIFICATION HISTORY */
/* */
/* March 25, 1993 */
/* DATAVG now looks for it's K500.CFG files in the DATAVG directory. */
/* Changed version to 1.10 in DATAVG.H RDH */
/* */
/* May 25, 1993 */
/* Fixed bug in channel setup function. It was possible to set */
/* channels greater than MAXCHAN. RDH */
/* */
/* ***** */

#define MAIN          /* MAIN includes the global data in this module */
#define DATAVG       /* Includes our definitions, other programs don't get them. */
#include "datavg.h"    /* define global data, DO NOT MOVE THIS LINE */

/* static function prototypes */
static int init_channels(void);
static void show_setup(void);
static void gen_show_setup(FILE *dev);
static void get_file_name(void);
static void check_channels(void);
static void get_data(void);
static int proc_function_key(int key);
```

```

static int get_window_number(void);
static int save_setup(void);
static void write_setup(void);
static void get_setup(void);
static void datavg_init(void);
static void get_box_configuration(void);
static void de_init(void);
static int test_kb(void);
static void new_line(void);
static void read_data(int num_chan);
static void write_data(int flag);

static void redraw_windows(int flag);
static void plot_data(int flag);
static void my_init_graph(void);
static void setup_window(int window);
static void def_window(int window);
static void redo_window(int window);
static void zoom_in_window(int window);
static void zoom_out_window(int window);
static void zoom(int window, float scale);
static void clr_window(int window);
static void set_driver_ptr(int slot);
static float timecode(void);
static int open_data_file(void);

static char Version[64];          /* Program version string */
static int MaxY;                  /* screen height */

/* ***** */
void main(void)
{
    /* INITIALIZE PROGRAM VARIABLES */
    datavg_init();

    /* MAIN MENU LOOP */
    while(1)
    {
        clrscr();

        printf("%s\n\n",Version);
        puts("    MAIN MENU\n");
        puts("  1)  SETUP CHANNELS");
        puts("  2)  SETUP SCREEN");
        puts("  3)  PRINT CHANNEL DATA");
        puts("  4)  CHECK CHANNEL SETUP");
        puts("  5)  SAVE SETUP DATA");
        puts("  6)  NAME DATA FILE");
        puts("  7)  GATHER DATA");
        puts("  8)  RECALL SETUP DATA");
        puts("  9)  EXIT TO DOS");
        fputs("\nENTER YOUR SELECTION ",stdout);

```

```

switch (getche())
{
    case '1':
    {
        if(init_channels() == 0)
            de_init();
        break;
    }

    case '2':
    {
        my_init_graph();
        break;
    }

    case '3':
    {
        show_setup();
        break;
    }

    case '4':
    {
        check_channels();
        break;
    }

    case '5':
    {
        save_setup();
        break;
    }

    case '6':
    {
        get_file_name();
        break;
    }

    case '7':
    {
        get_data();
        break;
    }

    case '8':
    {
        get_setup();
        break;
    }

    case '9':
    {
        de_init();
        break;
    }
}
/* EXIT TO DOS ROUTINE */

```

```

        default:
        {
            break;
        }
    }
}
} /* main() */

void interrupt new_ctl_C();
void interrupt new_ctl_break();
static void interrupt (*ctlc)();
static void interrupt (*ctlbrk)();

/* ***** */
/* INITIALIZATION CODE CALLED ONLY ONCE */
static void datavg_init(void)
{
    int k;

    open_graph(); /* open graphics */
    MaxY = getmaxy(); /* get screen size */

    if(MaxY < 200) /* setup menu bar position and size */
        WIN_BOTTOM = 5; /* CGA */

    else
        WIN_BOTTOM = 10; /* EGA or better */

    MENU_TOP = WIN_BOTTOM;
    closegraph(); /* restore screen */

    printer = stdprn;
    Data_file_name[0] = '\0';
    delay(0); /* calibrate delay routine */

    sprintf(Version," DATAVG FOR THE IBM PC\nVersion %3.1f, %s",
        VERNUM, __DATE__);

    /* read box configuration into a global structure */
    get_box_configuration();

    /* initialize some channel variables */
    for(k=1;k<=MAXCHAN;k++)
    {
        channels[k].name[0] = '\0'; /* clear name */
        channels[k].scale = 0.0; /* unused channel */
        channels[k].zero = 0.0; /* no offset */
        channels[k].trigger = 0.0; /* no trigger */
        channels[k].type = 'I'; /* input */
        channels[k].data = NULL; /* clear data pointer */
    }

    /* insure unused windows will not plot */
    for(k=0;k<MAXWINDOWS;k++)
        win_data[k].Xchan = -1;

```

```

/* Turn off CTRL-C and CTRL-BREAK checking */
Regs.h.ah = 0x33;
Regs.h.al = 0;          /* Get current flag */
int86(0x21,&Regs,&Regs);
Check = Regs.h.dl;      /* Save flag so it can be restored */

Regs.h.ah = 0x33;
Regs.h.al = 1;          /* Set flag */
Regs.h.dl = 0;          /* No Control-C checking */
int86(0x21,&Regs,&Regs);

ctlc = getvect(0x23);
ctlbrk = getvect(0x1b);
setvect(0x1b,new_ctl_break);
setvect(0x23,new_ctl_C);

/* Initialize some other global data */
strncpy(Test_ID,"DUMMY DUMMY DUMMY DUMMY DUMMY",sizeof(Test_ID));
plot_data_count = -1;   /* counter for points in plot buffers */
} /* datavg_init() */

/* ***** */
/* This function de-installs the CTRL-BREAK trap and cleans up */
/* before exiting the program. */
/* ***** */
static void de_init(void)
{
    closegraph();
    restorecrtmode();
    clrscr();

    /* restore Control-Break status */
    Regs.h.ah = 0x33;
    Regs.h.al = 01;      /* Set flag */
    Regs.h.dl = Check;    /* To previous value */
    int86(0x21,&Regs,&Regs);
    setvect(0x1b,ctlbrk);
    setvect(0x23,ctlc);

    puts("BYE");
    exit(0);
} /* de_init() */

/* ***** */
/* This function gets the interface box configuration and fills in. */
/* the box[] array. If the interface cannot auto-identify boards */
/* a configuration file will be read. */
/* ***** */
static void get_box_configuration(void)
{
    int k;
    int card_slot, max_chan;
    unsigned int SEG;
    char type;
    char name[sizeof(box[0].board)];
    FILE *cfg;

```

```

/* open configuration file */
if((cfg = fopen("\\DATAVG\\k500.cfg","r")) == NULL)
{
    clrscr();
    fputs("Configuration file K500.CFG not found, Aborting\n",stderr);
    exit(1);
}

/* read segment address from file and initialize the interface */
fgets(BUFFER,sizeof(BUFFER),cfg);
sscanf(BUFFER,"%x",&SEG);
init_500(SEG); /* init hardware */
set_timer(MS_COUNT,SEC_COUNT); /* set the counters */

/* read configuration from the file */
for(k=1;k<=10;k++)
{
    if(fgets(BUFFER,sizeof(BUFFER),cfg) == NULL)
        break;

    strtok(BUFFER,"");
    strncpy(name,BUFFER,sizeof(box[0].board));
    sscanf(strtok(NULL,"\\n"),"%d,%d,%c",&card_slot,&max_chan,&type);
    strcpy(box[card_slot].board,name);

    box[card_slot].card_slot = card_slot;
    box[card_slot].channels = max_chan;
    box[card_slot].type = type;
    box[k].last_chan = -1;

    set_driver_ptr(card_slot); /* put driver pointer in box[] */
}
fclose(cfg);
} /* get_box_configuration() */

/* ***** */
/* load driver pointers into the box structure. */
static void set_driver_ptr(int slot)
{
    int i;

    /* look up board name in master list */
    for(i=0;i<MAX_MODULES;i++)
        if(strcmp(box[slot].board,boards[i].name) == 0)
            break;

    if(i == MAX_MODULES)
        return; /* name not found */

    /* get data about this board and place in box structure */
    box[slot].driver = boards[i].driver;
} /* set_driver_ptr() */

```

```

/* ***** */
/* SETUP PHASE */
/* ***** */
/* CHANNEL SETUP */
/* ***** */
/* Get data from user and place in channels control structures */
static int init_channels(void)
{
    int k, n, return_val = 1;
    float val;
    int chan;
    char buf[64];

    /* build a board list string for prompts */
    strcpy(board_list, "Available boards are - \n\n Slot Name\n");
    for(k=1; k<=MAX_SLOT; k++)
    {
        sprintf(buf, "\n %2d ", k);
        strcat(board_list, buf);
        if(strlen(box[k].board))
        {
            strcat(board_list, box[k].board);
        }
    }

    strcat(board_list, "\nPlease select by number ? ");

    clrscr();
    fflush(stdin);
    fprintf(stdout, "\n\nEnter Test ID.\n Current value = (%s)\n", Test_ID);

    fgets(buf, sizeof(buf), stdin);
    strtok(buf, "\r\n");
    strupr(buf);

    if(strlen(buf) > 1)
        strcpy(Test_ID, buf);

    if(num_chan == 0)
    {
        num_chan = -1;
        n = -1;
    }
    else
        n = num_chan;

    /* get info for all channels */
    while(1)
    {
        clrscr();
        fputs("Enter channel data. Defaults are shown in ().\n\n", stderr);

        /* insist on a valid channel number */
        while(1)
        {
            fflush(stdin);
            fprintf(stdout, "\nCHANNEL # 0 - %d OR DONE (%d) ? ", MAXCHAN, num_chan+1);
            strupr(fgets(BUFFER, sizeof(BUFFER), stdin));

```



```

if(strncmp(BUFFER,"DONE",4) == 0)
    goto status;

if(sscanf(BUFFER,"%d",&n) == 1)
{
    if((n <= MAXCHAN) & (n >= 0))
        break;          /* valid channel selected */
}

else
{
    n = num_chan+1;      /* take default channel number */
    if(n <= MAXCHAN)     /* test for valid channel */
        break;
    printf("\nSelect a lower channel number or DONE\n");
}
}

if(num_chan < n)
    num_chan = n;

if(n == 0)
{
    fputs("\nCHANNEL 0 IS ALWAYS TIME.\n",stdout);
    strcpy(channels[0].name,"TIME");

    channels[0].scale = 1.0; /* no scaling on time */
    channels[0].card_slot = -1;
    channels[0].zero = 1.0; /* first point is always zero for TIME */
    channels[0].type = 'X'; /* type X is time */
}
/* n == 0 */

else
{
    /* get channel data name */
    fflush(stdin);

    fprintf(stdout,"TITLE FOR CHANNEL #%d (%s) ? ",
            n,channels[n].name);

    strupr(fgets(BUFFER,sizeof(BUFFER),stdin));
    strtok(BUFFER,"\r\n");

    if(BUFFER[0] != '\n')
    {
        strncpy(channels[n].name,BUFFER,sizeof(channels[n].name));
    }
    /* n != 0 */

    /* get channel scaling info */
    if(n != 0)
    {
        sprintf(BUFFER,"UNITS PER VOLT FOR CHANNEL %d (%g) ? ",
                n,channels[n].scale);
    }
}

```

```

        val = get_float(BUFFER,channels[n].scale);
        channels[n].scale = val;
    }
    /* n != 0 */

/* Get sample interval info */
    sprintf(BUFFER,"SAMPLE INTERVAL IN SCALED UNITS FOR CHANNEL %d (%g) ? ",
            n,channels[n].trigger);

    val = get_float(BUFFER,channels[n].trigger);

    channels[n].trigger = fabs(val);

/* Get offset info */
    if(n != 0)
    {
        fprintf(stdout,"IS FIRST POINT THE ZERO FOR %d (Y or N) (Y) ? ",n);
        fflush(stdin);
        strupr(fgets(BUFFER,sizeof(BUFFER),stdin));
        strtok(BUFFER,"\r\n");

        if(BUFFER[0] != '\n')
            channels[n].zero = (BUFFER[0] == 'Y') ? 1.0 : 0.0;

        else
            channels[n].zero = 1.0;
    }

/* get data about this board and place in channels structure */
    if(channels[n].card_slot > 0)
    {
        /* channel has been defined before */
        printf("Current board/channel = %s, %d. Any changes (Y or N) ? ",
            box[channels[n].card_slot].board, channels[n].chan);

        fflush(stdin);
        strupr(fgets(BUFFER,sizeof(BUFFER),stdin));
        strtok(BUFFER,"\r\n");

        if(BUFFER[0] == 'Y')
        {
            /* changes desired */
            get_valid_board(board_list, &k, &chan);
            channels[n].card_slot = box[k].card_slot;
            channels[n].type = box[k].type;
            channels[n].driver = box[k].driver;
            channels[n].chan = chan;
        }
    }

    else
    {
        /* channel has not been defined */
        get_valid_board(board_list, &k, &chan);
        channels[n].card_slot = box[k].card_slot;
        channels[n].type = box[k].type;
        channels[n].driver = box[k].driver;
        channels[n].chan = chan;
    }
    /* card_slot != 0 */

/* setup if this is a computed channel */
    if(channels[n].type == 'C')
        channels[n].driver(char,-1,n);
}
    /* n!= 0 */

```

```

/* allocate memory only if needed, if redoing a setup buffers exist */
if(channels[n].data == NULL)
{
    if((channels[n].data = farcalloc(BUFSIZE,sizeof(float))) == NULL)
    {
        fputs("Out of memory for data buffers, Aborting setup.\n",stderr);
        delay(10000);          /* wait so user can read message */
        return_val = 0;
        break;
    }
}
} /* data loop, gets data for all channels */

/* exit point for this function */
status:
clrscr();
gen_show_setup(stderr);
fputs("Enter to continue",stderr);
fflush(stdin);
getch();
return(return_val);
} /* init_channels() */

/* ***** */
/* SAVE SETUP DATA */
/* Setup file first line is the test ID. */
/* The second line contains the number of channels. */
/* The third line contains the number of windows. */
/* Lines four through MAXCHAN + three are the channel data. */
/* Computed channels insert additional lines. */
/* The last four lines contain the window data. */
/* ***** */
static int save_setup(void)
{
    while(1)
    {
        fflush(stdin);

        fputs("\n\nEnter setup file name. ? ",stdout);
        strupr(fgets(BUFFER,sizeof(BUFFER),stdin));
        strtok(BUFFER,"\r\n");
        validate_file_name(BUFFER);

        if(strlen(BUFFER)          /* insist on a file name */
        {

            if((data_file = fopen(BUFFER,"w")) == NULL)
            {
                fprintf(stderr,"Unable to open setup file %s.\n",BUFFER);
                fputs("Disk must be full\n",stderr);
                delay(10000);          /* wait so use can read message */
                return(0);
            }

            else
                break;
        }
    }
}

```

```

    write_setup();
    fclose(data_file);
    return(1);
} /* save_setup() */

/* ***** */
/* Write setup data to a file. */
/* Setup file first line is the test ID. */
/* The second line contains the number of channels. */
/* The third line contains the number of windows. */
/* Lines four and onward are the channel data. */
/* The last four lines contain the window data. */
/* ***** */
static void write_setup(void)
{
    int k, column;
    char name[sizeof(box[0].board)];

    fprintf(data_file, " %s\n", Test_ID);
    fprintf(data_file, "%d\n%d\n", num_chan, plot_windows);

    /* channel data */
    for(column=0, k=0; k<=MAXCHAN; k++)
    {
        name[0] = '\0';          /* clear board name */

        if(channels[k].scale != 0.0)
        {
            column++;            /* next output column */

            if(k != 0)            /* time channel does not have a board name */
            {
                strcpy(name, box[channels[k].card_slot].board);
            }
        }

        fprintf(data_file, "%g, %g, %g, %s, %d, %c, \"%s\", %d\n",
                    channels[k].scale,
                    channels[k].trigger,
                    channels[k].zero,
                    name,
                    channels[k].chan,
                    channels[k].type,
                    channels[k].name,
                    channels[k].scale != 0? column : 0);

        /* save computed channel setup data */
        if(channels[k].card_slot > 10)
            channels[k].driver(channels[k].chan, -2, 0);
    }
}

```

```

/* window data */
for(k=0;k<4;k++)
{
    fprintf(data_file,"%d, %d, %d, %d, %d, %d, %g, %g, %g, %g\n",
            win_data[k].Xchan,
            win_data[k].Ychan,
            win_data[k].SXmin,
            win_data[k].SXmax,
            win_data[k].SYmin,
            win_data[k].SYmax,
            win_data[k].UXmin,
            win_data[k].UXmax,
            win_data[k].UYmin,
            win_data[k].UYmax);
}
} /* write_setup() */

/* ***** */
/* RECALL SETUP DATA */
/* Setup file first line is the test ID. */
/* The second line contains the number of channels. */
/* The third line contains the number of windows. */
/* Lines four through MAXCHAN + three are the channel data. */
/* The last four lines contain the window data. */
/* ***** */
static void get_setup(void)
{
    int slot, k, j;
    char *ptr;
    char name[8];
    fpos_t Pos, NewPos;

    clrscr();

    while(1)
    {
        fflush(stdin);
        fputs("\n\nEnter setup file name.",stderr);
        fputs("\nBlank entry to return to main menu ? ",stderr);
        strupr(fgets(BUFFER,sizeof(BUFFER),stdin));

        if(strlen(BUFFER) < 2)
            return;

        strtok(BUFFER,"\r\n");

        if((data_file = fopen(BUFFER,"r")) != NULL)
            break;
    }

    /* determine length of setup file so we do not read too much or little. */
    k = 0;
    while(fgets(BUFFER,sizeof(BUFFER),data_file))
        k++;

    k -= 4;          /* total lines including header */

```

```

rewind(data_file);

/* find position of window data in file */
for(;k;k--)
    fgets(BUFFER,sizeof(BUFFER),data_file);

fgetpos(data_file,&Pos);

rewind(data_file);

/* get test ID */
fgets(BUFFER,sizeof(BUFFER),data_file);
strtok(BUFFER,"\r\n");
strncpy(Test_ID,BUFFER,sizeof(Test_ID));

/* get channel and window counts */
fscanf(data_file,"%d\n",&num_chan);
fscanf(data_file,"%d\n",&plot_windows);

/* read data for all channels and fill in structures */
for(k=0;k<=MAXCHAN;k++)
{
    if(fgets(BUFFER,sizeof(BUFFER),data_file) == NULL)
    {
        for(k=0;k<10;k++)
            puts("\007");

        puts(" Unexpected end of setup file encountered");
        puts(" Aborting RECALL SETUP operation \007");

        delay(5000);
        return;
    }

    /* channel name may be quote delimited, remove the trailing quote if so */
    if((ptr = strrchr(BUFFER,'\''')) != NULL)
    {
        *ptr = '\0';          /* terminate string at last quote */
        ptr = strrchr(BUFFER,'\''')+1;    /* find first quote */
    }

    sscanf(strtok(BUFFER,","),"%f",&channels[k].scale);
    sscanf(strtok(NULL,","),"%f",&channels[k].trigger);
    sscanf(strtok(NULL,","),"%f",&channels[k].zero);
    strcpy(name,strtok(NULL,")+1);    /* get board name */
    sscanf(strtok(NULL,","),"%d",&channels[k].chan);
    sscanf(strtok(NULL,")+1,"%c",&channels[k].type);

    if(ptr != NULL)
        strncpy(channels[k].name,ptr,sizeof(channels[k].name));

    else
        strncpy(channels[k].name,strtok(NULL,","\0")+1,sizeof(channels[k].name));
}

```

```

    if(channels[k].scale != 0.0)
    {
/* look up board name in box list to find slot number */
        if(k != 0)
        {
            for(slot=1;slot<=MAX_SLOT;slot++)
            {
                if((strlen(name) > 0) && (strcmp(box[slot].board,name) == 0))
                {
                    break;          /* jump out of search loop */
                }
            }

            if(slot == MAX_SLOT)
            {
                puts("Invalid setup file, this box is missing a required board");
                printf("Missing board is %s\n",name);

                delay(10000);
                exit(1);          /* name not found */
            }

/* set driver pointers & other data */
            channels[k].card_slot = slot;
            channels[k].driver = box[slot].driver;
        }

/* allocate memory only if needed */
        if((channels[k].data = farcalloc(BUFSIZE,sizeof(float))) == NULL)
        {
            fputs("Out of memory for data buffers, Aborting setup.\n",stderr);

            delay(10000);          /* wait so user can read message */
            exit(1);
        }

/* restore computed channel setup data */
        if(channels[k].card_slot > 10)
            channels[k].driver(channels[k].chan,-3,0);

        fgetpos(data_file,&NewPos);
        if(NewPos == Pos)
            break;
    }

/* load window data */
    rewind(data_file);
    fsetpos(data_file,&Pos);

```

```

for(k=0;k<4;k++)
{
    fgets(BUFFER,sizeof(BUFFER),data_file);
    j = sscanf(BUFFER,"%d, %d, %d, %d, %d, %d, %f, %f, %f, %f,\n",
        &win_data[k].Xchan,
        &win_data[k].Ychan,
        &win_data[k].SXmin,
        &win_data[k].SXmax,
        &win_data[k].SYmin,
        &win_data[k].SYmax,
        &win_data[k].UXmin,
        &win_data[k].UXmax,
        &win_data[k].UYmin,
        &win_data[k].UYmax);

    if((j != 10) | (j == EOF))
    {
        for(slot=0;slot<10;slot++)
            puts("\007");

        printf(" Invalid window %d data encountered\n",k);
        puts(" Aborting RECALL SETUP operation \007");

        delay(5000);
        return;
    }
}
/* adapt screen position to resolution */
j = (((WIN_TOP - WIN_BOTTOM) / 2) + WIN_BOTTOM);

switch(plot_windows)
{
    case 1:
    {
        win_data[0].SYmin = WIN_BOTTOM;
        break;
    }

    case 2:
    {
        win_data[0].SYmin = j;
        win_data[1].SYmax = j;
        win_data[1].SYmin = WIN_BOTTOM;
        break;
    }

    case 3:
    case 4:
    {
        win_data[0].SYmin = j;
        win_data[1].SYmin = j;
        win_data[2].SYmax = j;
        win_data[2].SYmin = WIN_BOTTOM;
        win_data[3].SYmax = j;
        win_data[3].SYmin = WIN_BOTTOM;
        break;
    }
}
fclose(data_file);
} /* get_setup() */

```



```

/* ***** */
/* GRAPHICS SETUP */
/* ***** */
/* initialize the screen */
static void my_init_graph(void)
{
    int i;
    int next_window = 1;          /* window counter */

    win_data[0].SXmax = 0;        /* used for error detection */

    while(1)
    {
        fprintf(stderr, "\n\nCurrent window count = %d\n", plot_windows);
        sprintf(BUFFER, "Enter number of windows to be displayed 1-4 (%d) ? ",
            plot_windows);

        plot_windows = get_int(BUFFER, plot_windows);

        switch(plot_windows)
        {
            case 1:
            {
                /* only one window */
                win_data[0].SXmin = WIN_LEFT;
                win_data[0].SXmax = WIN_RIGHT;
                win_data[0].SYmin = WIN_BOTTOM;
                win_data[0].SYmax = WIN_TOP;
                break;
            }

            case 2:
            {
                /* top window */
                win_data[0].SXmin = WIN_LEFT;
                win_data[0].SXmax = WIN_RIGHT;
                win_data[0].SYmin = (((WIN_TOP - WIN_BOTTOM) / 2) + WIN_BOTTOM);
                win_data[0].SYmax = WIN_TOP;

                /* bottom window */
                win_data[1].SXmin = WIN_LEFT;
                win_data[1].SXmax = WIN_RIGHT;
                win_data[1].SYmin = WIN_BOTTOM;
                win_data[1].SYmax = (((WIN_TOP - WIN_BOTTOM) / 2) + WIN_BOTTOM);
                break;
            }

            case 3:
            case 4:
            {
                /* top left window */
                win_data[0].SXmin = WIN_LEFT;
                win_data[0].SXmax = (((WIN_RIGHT - WIN_LEFT) / 2) + WIN_LEFT);
                win_data[0].SYmin = (((WIN_TOP - WIN_BOTTOM) / 2) + WIN_BOTTOM);
                win_data[0].SYmax = WIN_TOP;

```

```

/* top right window */
win_data[1].SXmin = (((WIN_RIGHT - WIN_LEFT) / 2) + WIN_LEFT);
win_data[1].SXmax = WIN_RIGHT;
win_data[1].SYmin = (((WIN_TOP - WIN_BOTTOM) / 2) + WIN_BOTTOM);
win_data[1].SYmax = WIN_TOP;

/* bottom left window */
win_data[2].SXmin = WIN_LEFT;
win_data[2].SXmax = (((WIN_RIGHT - WIN_LEFT) / 2) + WIN_LEFT);
win_data[2].SYmin = WIN_BOTTOM;
win_data[2].SYmax = (((WIN_TOP - WIN_BOTTOM) / 2) + WIN_BOTTOM);

/* bottom right window */
win_data[3].SXmin = (((WIN_RIGHT - WIN_LEFT) / 2) + WIN_LEFT);
win_data[3].SXmax = WIN_RIGHT;
win_data[3].SYmin = WIN_BOTTOM;
win_data[3].SYmax = (((WIN_TOP - WIN_BOTTOM) / 2) + WIN_BOTTOM);
break;
}

default:
{
    puts("Invalid window count");
    break;
}
}
if(win_data[0].SXmax != 0)
    break;
}

while(1) /* do windows until user finished */
{
    if(plot_windows > 1)
    {
        sprintf(BUFFER,"Setup which window 1-%d (%d) -1 to end ? ",
                plot_windows, next_window);
        i = get_int(BUFFER,next_window);

        if(i == -1)
            break;

        if((i >= 1) & (i <= plot_windows))
        {
            setup_window(i-1);
        }

        next_window = i+1;
    }
    else
    {
        setup_window(0);
        next_window++;
    }
}

/* see if we are done */
if(next_window > plot_windows)
{
    fputs("Finished Y or N (N) ? ",stdout);
    fflush(stdin);
}

```

```

        if(toupper(getche()) == 'Y')
        {
            break;
        }

        puts("");
    }
}
} /* my_init_graph() */

/* ***** */
/* setup a window scaled as the user desires */
static void setup_window(int window)
{
    float min, max;
    int chan;

    /* Get X-Axis channel for this window */
    sprintf(BUFFER,
            "Enter channel to plot on window %d X-Axis (%d) or (-1 = none) ? ",
            window+1, win_data[window].Xchan);

    chan = get_int(BUFFER, win_data[window].Xchan);
    win_data[window].Xchan = chan;

    if(chan == -1)
        return;

    /* Get Y-Axis channel for this window */
    sprintf(BUFFER, "Enter channel to plot on window %d Y-Axis (%d) ? ",
            window+1, win_data[window].Ychan);

    chan = get_int(BUFFER, win_data[window].Ychan);
    win_data[window].Ychan = chan;

    /* Get X-Axis minimum value to plot */
    sprintf(BUFFER, "Enter X-Axis minimum value (%g) ? ",
            win_data[window].UXmin);

    min = get_float(BUFFER, win_data[window].UXmin);

    /* Get X-Axis maximum value to plot */
    sprintf(BUFFER, "Enter X-Axis maximum value (%g) ? ",
            win_data[window].UXmax);

    max = get_float(BUFFER, win_data[window].UXmax);

    /* store user data in proper order, swap if needed */
    if(min <= max)
    {
        win_data[window].UXmin = min;
        win_data[window].UXmax = max;
    }

    else
    {
        win_data[window].UXmin = max;
        win_data[window].UXmax = min;
    }
}

```



```

/* ***** */
/* CHECKS IF CHANS ARE OK */
/* This function reads and displays data from each active channel. */
/* Data is shown in VOLTS for ease in comparison to machine indicators */
/* Temperature channels will display in unusual units. */
static void check_channels(void)
{
    int l;

    puts("\n\n");

    for(l=1;l<=MAXCHAN;l++)
    {
        if(channels[l].scale != 0.0)
        {
            while(1)
            {
                read_data(num_chan);          /* read the channels */

                D[l] += channels[l].zero;      /* undo the scaling */
                D[l] /= channels[l].scale;

                printf("\n%s\n",channels[l].name);
                printf("FOR CHAN %d VOLTAGE IS %f\n",l,D[l]);
                printf(" CHANGE CHAN %d, PRESS RETURN ",l);

                fflush(stdin);
                strupr(gets(BUFFER));

                read_data(num_chan);          /* read the channels */

                D[l] += channels[l].zero;      /* undo the scaling */
                D[l] /= channels[l].scale;

                printf("NEW READING FOR %d IS %f\n",l,D[l]);
                fputs("PRESS RETURN OR A(AGAIN) ",stdout);
                fflush(stdin);
                strupr(gets(BUFFER));

                if(strcmp(BUFFER,"A"))
                    break;
            }
        }
    }
} /* check_channels() */

/* ***** */
/* Check file names and remove characters DOS doesn't like */
/* ***** */
void validate_file_name(char *name)
{
    char *ptr = name;
    char *ptr1 = "*,$;<>?=";

    while(1)          /* strip out control characters */
    {
        if(*ptr == NULL)
            break;
    }
}

```

```

    if((*ptr <= 'z') & (*ptr > ' '))
        ptr++;

    else
    {
        *ptr = '\0';
        strcat(name, (ptr+1));
    }
}

while(1)          /* strip out other invalid punctuation characters */
{
    if(*ptr1 == NULL)
        break;

    ptr = strchr(name, *ptr1++);

    if(ptr != NULL)
    {
        *ptr = '\0';
        strcat(name, ++ptr);
    }
}

/* truncate name field if needed */
if((ptr = strrchr(name, '\\')) == NULL)
    ptr = strchr(name, ':');    /* no sub-directory on path */

if(ptr == NULL)            /* path or drive not present */
    ptr = name;

else
    ptr++;

if((ptr1 = strchr(name, '.')) != NULL)    /* type field present */
{
    if((ptr1 - ptr) > 8)
    {
        *(ptr+8) = '\0';
        strcat(name, ptr1);
    }

    else
    {
        if(strlen(ptr) > 8)
            *(ptr+8) = '\0';
    }
}

else
{
    if(strlen(ptr) > 8)
        *(ptr+8) = '\0';
}

/* truncate type field if needed */
if((ptr = strchr(name, '.')) != NULL)
    if(strlen(ptr) > 3)
        *(ptr+4) = '\0';

```

```

} /* validate_file_name() */

/* ***** */
/* RUN PHASE */
/* ***** */
/* GET FILE NAME */
static void get_file_name(void)
{
    /* SET FILE SEQUENCE NUMBER TO ZERO */
    SEQUENCE = 0;

    fflush(stdin);
    fputs("\n\nENTER FILE NAME FOR DATA STORAGE ? ",stdout);

    /* make sure we get a file name */
    while(1)
    {
       strupr(fgets(Data_file_name,sizeof(Data_file_name),stdin));
        strtok(Data_file_name, ".\\r\\n");

        validate_file_name(Data_file_name);

        if(strlen(Data_file_name) > 0)
            break;
    }

    /* make sure we get a number */
    while(1)
    {
        fflush(stdin);
        fputs("HOW MANY DATA POINTS BEFORE CLOSING OUTPUT FILE ? ",stdout);

        if(fscanf(stdin,"%d",&Points_per_file) == 1)
            if(Points_per_file > 0)
                break;
    }
} /* get_file_name() */

/* ***** */
/* menu bar text */
/* there must be 20 strings defined. The first 10 print on the */
/* bottom of the screen. The next 10 print above them. */
/* ***** */
char far *titles[20] =
{
    "Take Pt",          /* F1 take a point */
    "Reset W",         /* F2 reset window to full scales */
    "Zoom in",         /* F3 zoom and center a window */
    "Zoom out",        /* F4 shrink and center a window */
    "Define W",        /* F5 redefine a window completely */
    "Clr Win",         /* F6 clear data from a window */
    "Clr All",         /* F7 clear data from all windows */
    "New File",        /* F8 start a new file */
    "End Test",        /* F9 end the test */
    "",               /* F10 */

    "F1", "F2", "F3", "F4", "F5", "F6", "F7", "F8", "F9", "F10"
};

```

```

/* ***** */
/* This is the main acquisition loop. START DATA RECORDING */
static void get_data(void)
{
    int k, j;

    if(strlen(Data_file_name) == 0)          /* Be sure we have a file */
        get_file_name();

    if(open_data_file() == 0)                /* make the first data file */
        return;

    base_time = 0.0;                        /* time offset, holds starting time */
    rel_time = 0.0;                         /* time from start of program */
    plot_data_count = -1;                   /* counter for points in plot buffers */
    Points_this_file = 0;

    /* CLEAR DATA ARRAY */
    for(j=0;j<=MAXCHAN;j++)
    {
        D[j]=0.0;
    }

    /* WAIT FOR RETURN BEFORE STARTING */
    fputs("\n\nPress enter to start test",stderr);
    fflush(stdin);
    fgets(BUFFER,sizeof(BUFFER),stdin);

    /* Draw windows */
    redraw_windows(0);                      /* draw windows but no plot */

    /* Write data file header, setup data in first file. */
    fprintf(data_file,"%s\n",Version);

    write_setup();

    /* time stamp the file */
    ftime(&start_time);

    fprintf(data_file,"\n%s\n",asctime(localtime(&start_time.time)));

    /* put channel names in the file */
    for(k=0;k<=num_chan;k++)
        if(channels[k].scale != 0.0)
            fprintf(data_file," \"%s\"",channels[k].name);

    new_line();

    /* LOAD ZEROS */
    read_data(num_chan);                    /* initial data values */

    for(k=1;k<=num_chan;k++)                /* place zeros in channel structures */
        if(channels[k].zero != 0.0)         /* non-zero is the offset flag */

    /* remove previous offset and store the new one */
        channels[k].zero = D[k] + channels[k].zero;

```



```

/* record initial offsets in file */
write_data(0);                                /* save current time offset */

/* close file containing setup data (name.HDR) */
fclose(data_file);

/* real data starts in file name.DAT */
if(open_data_file() == 0)                      /* make the data file */
    return;

/* initialize data reporting and plots */
base_time = rel_time;                          /* establish time offset */

read_data(num_chan);                          /* read initial values and remove offsets */

/* place in plot buffers and file */
write_data(0);

Total_points = (long)plot_data_count;

/* COLLECT DATA */
while(1)                                       /* do until user requests stop */
{
    read_data(num_chan);                      /* get data from each channel */

/* CHECK FOR LARGE ENOUGH CHANGE */
for(k=0;k<=num_chan;k++)
{
    if(channels[k].scale != 0.0)              /* test only active channels */
    {
        if((fabs(D[k] - channels[k].data[plot_data_count]))
            >= channels[k].trigger)
        {
            write_data(1);                    /* write all data and plot */
            break;                            /* no need to test further */
        }
    }
}

/* TEST KEYBOARD INTERRUPT STATUS */
if(proc_function_key(test_kb()) == 1)
    return;                                   /* end of data collection loop */
} /* get_data() */

/* ***** */
/* This function processes function keys for get_data() */
/* Returns 1 if program should exit to main menu, error or end of test */
static int proc_function_key(int key)
{
    switch(key)
    {
        case 0:                               /* no function keys pressed */
        {
            break;
        }
    }
}

```

```

case 1:                                /* F1 write a data point */
{
    write_data(1);
    break;
}

case 2:                                /* F2 Redo window */
{
    redo_window(get_window_number());
    break;
}

case 3:                                /* F3 zoom in window */
{
    zoom_in_window(get_window_number());
    break;
}

case 4:                                /* F4 Zoom out window */
{
    zoom_out_window(get_window_number());
    break;
}

case 5:                                /* F5 Redefine window */
{
    def_window(get_window_number());    /* define the window to use */
    break;
}

case 6:                                /* F6 Clear data from a window */
{
    clr_window(get_window_number());
    break;
}

case 7:                                /* F7 Clear data from all windows */
{
    closegraph();                      /* reset screen to text mode and clear */
    clrscr();
    clr_window(-1);                    /* clear all active windows */
    break;
}

case 8:                                /* F8 Start new file */
{
    closegraph();
    clrscr();
    fprintf(stdout, "\tTOTAL POINTS %ld\n", Total_points);
    fclose(data_file);
    get_file_name();
    SEQUENCE = 1;                      /* no header for this name */

    if(open_data_file() == 0)          /* make the data file */
        return(1);                    /* error */
}

```

```

        redraw_windows(1);                /* redraw and replot */
        Points_this_file = 0;
        break;
    }

    case 9:                                /* F9 End test */
    {
        closegraph();
        clrscr();
        fprintf(stdout, "\tTOTAL POINTS %ld\n", Total_points);
        fputs("\nDo you really want to end this test (Y or N) ? ", stderr);

        if(toupper(getche()) != 'Y')
        {
            redraw_windows(1);
            break;
        }

        fclose(data_file);                /* close file */
        Data_file_name[0] = '\0';          /* dump old file name */
        return(1);                         /* back to main menu */
    }

    default:
        break;                            /* end of switch */
}

return(0);
} /* proc_function_key() */

/* ***** */
/* get a valid window number. If only one window is in use it is */
/* returned as default. */
static int get_window_number(void)
{
    int i, j, window;

    /* reset screen to text mode and clear */
    closegraph();
    clrscr();

    /* check for one window in use */
    if(plot_windows == 1)
        return(0);

    /* check for multi-window screen with only one in use */
    for(i=0, j=0; i<plot_windows; i++)
    {
        if(win_data[i].Xchan != -1)
            j++, window=i;
    }

    if(j==1)
        return(window);
}

```

```

/* Multiple windows in use, get the desired one from user */
while(1)
{
    fflush(stdin);
    fprintf(stderr, " Which window (1 - %1d) ? ", plot_windows);

    if(scanf("%d",&window) == 1)
        if((window >= 1) & (window <= plot_windows))
            break;
}

return(--window);
} /* get_window_number() */

/* ***** */
/* TAKE A READING AND RETURN IN THE D[] ARRAY */
static void read_data(int num_chan)
{
    int k, j;

    /* read from each channel and scale readings into user units */
    D[0] = timecode();

    /* clear accumulators */
    for(k=1;k<=num_chan;k++)
        D[k] = 0.0;

    /* Read and average all active channels */
    for(j=0;j<Num_to_average;j++)
    {
        for(k=1;k<=num_chan;k++)          /* scan all channels */
        {
            if(channels[k].scale != 0.0)  /* process only if in use */
            {

                /* get raw reading in volts and divide by Num_to_average then accumulate */
                D[k] += (channels[k].driver(channels[k].chan,
                                           channels[k].card_slot, 1)
                        / (float)Num_to_average);
            }
        }
    }

    /* complete scaling and offsetting */
    for(k=1;k<=num_chan;k++)
    {
        D[k] *= channels[k].scale;
        D[k] -= channels[k].zero;
    }
} /* read_data() */

```

```

/* ***** */
/* return a time in seconds from unsigned millisecond and seconds counts. */
/* adjust for rollover in raw_time at 65536 seconds. */
/* update global time value (rel_time). */
/* ***** */
static float timecode(void)
{
    static unsigned long seconds;      /* running seconds counter */
    static unsigned long carry_time;   /* working buffer */
    static unsigned long rollover_detect; /* previous seconds */
    static unsigned int ms;            /* milliseconds at this reading */

    /* read the timer */
    read_timer(&Ktime);                /* get time from counter */

    /* compute and save time in seconds and milliseconds */
    ms = MS_COUNT - Ktime.low;         /* MS_COUNT is a defined constant */

    seconds = (long)(SEC_COUNT - Ktime.high);

    if(seconds < rollover_detect)
        carry_time += SEC_COUNT;       /* SEC_COUNT is a defined constant */

    /* save current time reading for rollover detection */
    rollover_detect = seconds;

    rel_time = (((double)(seconds + carry_time)) + (((double)ms) / 1000.0))
               - base_time;

    /* return value will round off at high values but is used only for triggering */
    return((float)rel_time);
} /* timecode() */

/* ***** */
/* Write data to the file. */
/* If flag is set this a new data point to be stored in the next buffer */
/* location. Otherwise it is an initial point. Place the point in */
/* the file in any case */
static void write_data(int flag)
{
    int k;
    int first = 1;

    if(flag)
    {
        plot_data_count++;              /* set storage pointer for this event */
        plot_data_count %= BUFSIZE;
    }

    if(channels[0].scale != 0.0)
    {
        fprintf(data_file, "%12.3lf", rel_time);    /* write time stamp */
        first = 0;
    }
}

```

```

for(k=1;k<=num_chan;k++)
{
    if(channels[k].scale != 0.0)                /* put data in a file */
                                                /* write data value */
    {
        if(first)
        {
            fprintf(data_file,"%12.6g",D[k]);    /* first column */
            first = 0;
        }
        else
        {
            fprintf(data_file," %12.6g",D[k]);    /* not first column */
        }
    }
}

new_line();

Total_points++;                                /* test for end of this file */
Points_this_file++;

if(Points_this_file >= Points_per_file)
{
    fclose(data_file);

    if(open_data_file() == 0)
        return;                                /* Open Error */

    Points_this_file = 0;
}

/* store data in buffer */
for(k=0;k<=num_chan;k++)
{
    if(channels[k].scale != 0.0)
    {
        channels[k].data[plot_data_count] = D[k];
    }
}

plot_data(flag);                                /* plot the current data points */
} /* write_data() */

/* ***** */
/* GRAPHICS ROUTINES */
/* ***** */
/* Plot the data on the screen */
/* If flag is non-zero the point is to be plotted */
static void plot_data(int flag)
{
    int window;
    int end = plot_data_count;

    for(window=0;window<plot_windows;window++)
    {
        /* do not select inactive windows */
        if(win_data[window].Xchan != -1)
        {
            select_window(window);
        }
    }
}

```

```

        if(flag)
        {
            /* draw line to this point */
            draw_line_to(channels[win_data[window].Xchan].data[end],
                        channels[win_data[window].Ychan].data[end]);
        }

        else
        {
            /* set origin for this plot */
            move_to(channels[win_data[window].Xchan].data[0],
                    channels[win_data[window].Ychan].data[0]);
        }
    }
}
} /* plot_data() */

/* ***** */
/* Define a window with new axes and plot the data buffer in it */
/* Axes are scaled to full scale for the channels in this window. */
/* The screen is completely redrawn */
static void def_window(int window)
{
    setup_window(window);
    redraw_windows(1); /* redraw and replot */
} /* def_window() */

/* ***** */
/* Redo a window with new axes and plot the data buffer in it */
/* Axes are scaled to full scale for the channels in this window. */
/* The screen is completely redrawn */
/* ***** */
static void redo_window(int window)
{
    float X, Y;

    /* absolute value of full scale for this channel */
    /* scale is in units per volt. *10.0 compensates for 10V full scale */
    /* input range */

    X = fabs(channels[win_data[window].Xchan].scale * 10.0);
    Y = fabs(channels[win_data[window].Ychan].scale * 10.0);

    /* put new plot limits in window control structure */
    win_data[window].UXmin = -X; /* lower left corner */
    win_data[window].UYmin = -Y;

    win_data[window].UXmax = X; /* upper right corner */
    win_data[window].UYmax = Y;

    redraw_windows(1); /* redraw and replot */
} /* redo_window() */

/* ***** */
/* Zoom window in. The window is magnified by Zoom_Scale and the */
/* last data point is centered. The screen is completely redrawn */
/* ***** */
static void zoom_in_window(int window)
{
    zoom(window, Zoom_Scale);
    redraw_windows(1); /* redraw and replot */
}

```

```

} /* zoom_in_window() */

/* ***** */
/* Zoom window out. The window is demagnified by Zoom_Scale and the */
/* last data point is centered. The screen is completely redrawn */
/* ***** */
static void zoom_out_window(int window)
{
    zoom(window, 1.0 / Zoom_Scale);
    redraw_windows(1); /* redraw and replot */
} /* zoom_out_window() */

/* ***** */
/* This is a generic zoom function used by the above functions */
/* ***** */
static void zoom(int window, float scale)
{
    float x, deltax, y, deltay;

    if(win_data[window].Xchan != -1) /* only zoom active windows */
    {
        /* Get last data point */
        x = channels[win_data[window].Xchan].data[plot_data_count];

        y = channels[win_data[window].Ychan].data[plot_data_count];

        /* compute offsets, (range*scale), then divide by 2. This provides */
        /* offsets each side of the last point */

        deltax = ((win_data[window].UXmax - win_data[window].UXmin) * scale) / 2.0;
        deltay = ((win_data[window].UYmax - win_data[window].UYmin) * scale) / 2.0;

        /* put new plot limits in window control structure */
        win_data[window].UXmin = x - deltax; /* lower left corner */
        win_data[window].UYmin = y - deltay;

        win_data[window].UXmax = x + deltax; /* upper right corner */
        win_data[window].UYmax = y + deltay;
    }
} /* zoom() */

/* ***** */
/* Clear data from a window. All data is erased from the specified */
/* window by replacing it with the last data value. The last point */
/* remains to initialize the plot. If the window number is -1 all */
/* windows will be cleared. */
static void clr_window(int window)
{
    int i, k, x, y;
    float X, Y;

    if(window == -1)
    {
        for(i=0; i<MAXWINDOWS; i++)
        {
            if(win_data[i].Xchan != -1) /* Active windows only */
            {
                x = win_data[i].Xchan;
                y = win_data[i].Ychan;
            }
        }
    }
}

```



```

/* Get last data values into local variables to avoid repeated indexing */
X = channels[x].data[plot_data_count];
Y = channels[y].data[plot_data_count];

    for(k=0;k<BUFSIZE;k++)
    {
        channels[x].data[k] = X;      /* Fill buffers */
        channels[y].data[k] = Y;
    }
}
}

else
{
    x = win_data[window].Xchan;
    y = win_data[window].Ychan;

/* Get last data values into local variables to avoid repeated indexing */
X = channels[x].data[plot_data_count];
Y = channels[y].data[plot_data_count];

    for(k=0;k<BUFSIZE;k++)
    {
        channels[x].data[k] = X;      /* Fill buffers */
        channels[y].data[k] = Y;
    }
}

redraw_windows(1);                      /* redraw and replot */
} /* clr_window() */

/* ***** */
/* redraw all active windows and optionally replot the data. */
/* replot if flag is non-zero. */
/* ***** */
static void redraw_windows(int flag)
{
    int i, j;
    char title[16];

    open_graph();                      /* setup graphics */

    for(i=0;i<plot_windows;i++)        /* redefine and plot all windows */
    {
        if(win_data[i].Xchan != -1)
        {
            define_window(i,win_data[i].SXmin,
                          win_data[i].SYmin,
                          win_data[i].SXmax,
                          win_data[i].SYmax,
                          win_data[i].UXmin,
                          win_data[i].UYmin,
                          win_data[i].UXmax,
                          win_data[i].UYmax);

```

```

        sprintf(title,"Window %1d",i+1);
        define_header(i,title);
        draw_axes(i,5,5,channels[win_data[i].Xchan].name,
                  channels[win_data[i].Ychan].name);

/* ***** */
/* Plot_data_count indexes the last data placed in the buffer. */
/* Start plotting from the oldest point (plot_data_count+1) */
/* and continue to the end of the buffer. Then precede to the */
/* last point inserted (plot_data_count). */
/* ***** */

        if(flag)
        {
/* ptr will be (plot_data_count + 2) if the buffer has wrapped around. */
/* Otherwise ptr starts at 1. This logic starts the plot at the oldest */
/* data and prevents plotting parts of the buffer which have not been */
/* filled. */

/* get data buffer pointers */
                float far *X = channels[win_data[i].Xchan].data;
                float far *Y = channels[win_data[i].Ychan].data;
                int ptr = ((Total_points - (long)plot_data_count) > 0) ?
                        (plot_data_count + 2) : 1;

/* starting point, move to the oldest point */
                move_to(X[ptr -1], Y[ptr -1]);

/* do the plot with wrap around until the latest point is encountered */
                j = 1;                                /* default for one data point */

                if(Total_points > 11)
                {
                        for(j=ptr;j!=plot_data_count;j++)
                        {
                                j %= BUFSIZE;
                                draw_line_to(X[j], Y[j]);
                        }
                }

/* complete the line to the last point */
                draw_line_to(X[j], Y[j]);
        }

}

}

if(MaxY < 200)
        menu_bar(MENU_TOP,10,titles);                /* make menu bar */

else
        menu_bar(MENU_TOP,20,titles);

} /* redraw_windows() */

```

```

/* ***** */
/* UTILITY ROUTINES */
/* ***** */
/* NEW LINE SUBROUTINE */
/* This is a generic function to allow for multiple output streams */
static void new_line(void)
{
    fputs("\n",data_file);
} /* new_line() */

/* ***** */
/* prompt and get an integer value from the user */
/* a valid number or blank line is required */
/* a blank line will cause return of the default value. */
/* ***** */
int get_int(char *prompt, int def)
{
    int val;
    char buf[32];

    while(1)
    {
        fflush(stdin);
        fputs(prompt,stderr);
        strupr(fgets(buf,sizeof(buf),stdin));
        strtok(buf,"\r\n");

        if(buf[0] == '\n')
        {
            val = def;          /* take default value */
            break;
        }

        if(sscanf(buf,"%d",&val) == 1) /* scan input */
            break;              /* take input value */
    }

    return(val);
} /* get_int() */

/* ***** */
/* prompt and get a float value from the user */
/* a valid number or blank line is required */
/* a blank line will cause return of the default value. */
/* ***** */
float get_float(char *prompt, float def)
{
    float val;
    char buf[32];

    while(1)
    {
        fflush(stdin);
        fputs(prompt,stderr);
        strupr(fgets(buf,sizeof(buf),stdin));
        strtok(buf,"\r\n");
    }

```

```

        if(buf[0] == '\n')
        {
            val = def;                /* take default value */
            break;
        }

        if(sscanf(buf,"%g",&val) == 1)    /* scan input */
            break;                        /* take input value */
    }

    return(val);
} /* get_float() */

/* ***** */
/* This function tests for keyboard input and returns a key code */
/* indicating which function key was pressed. F1 - F9 are supported. */
/* Any other key returns zero. */
/* ***** */
static int test_kb(void)
{
    if(kbhit())
    {
        if(getch() == 0)
        {
            switch(getch())
            {
                case 59:                /* F1 */
                    return(1);

                case 60:                /* F2 */
                    return(2);

                case 61:                /* F3 */
                    return(3);

                case 62:                /* F4 */
                    return(4);

                case 63:                /* F5 */
                    return(5);

                case 64:                /* F6 */
                    return(6);

                case 65:                /* F7 */
                    return(7);

                case 66:                /* F8 */
                    return(8);

                case 67:                /* F9 */
                    return(9);

                default:                /* Unused function key. */
                    return(0);
            }
        }
    }
}

```

```

    return(0);                /* No key pressed. */
} /* test_kb() */

/* ***** */
/* function to open files and report on detected errors */
/* returns zero on error, one if no error. */
/* If SEQUENCE = 0 the type is .HDR, else, the type is .DAT */
/* ***** */
static int open_data_file(void)
{
    /* remove old file type and replace it */
    strcpy(filename,Data_file_name);

    if(SEQUENCE == 0)
    {
        strcat(filename,".HDR");
        SEQUENCE = 1;
    }

    else
    {
        strcat(filename,".DAT");
    }

    /* Open in append mode so we do not destroy data if the file exists */

    if((data_file = fopen(filename,"a")) == NULL)
    {
        clrscr();
        fprintf(stderr,"\n\nUnable to open data file %s\n",filename);
        fputs("Disk or Directory must be full\n",stderr);

        delay(10000);          /* wait so user can read the message */
        return(0);             /* ERROR */
    }

    return(1);                 /* OK */
} /* open_data_file() */

/* ***** */
/* get a valid board name and channel number form the user */
/* Input data is a pointer to the prompt text. */
/* Returns an index into the box[] array and the board channel to */
/* be used. */
/* ***** */
void get_valid_board(char *text, int *box_index, int *chan)
{
    int k, def;
    char buf[16];

    while(1)                   /* insist on a valid board name */
    {
        fputs("SELECT BOARD FOR THIS CHANNEL\n",stderr);
        fputs(text,stderr);

```

```

        if(scanf("%d",&k) == 1)
        {
            if((k > 0) && (k <= MAX_SLOT) && (strlen(box[k].board) > 0))
            {
                *box_index = k;
                break;
            }
        }
    }

    def = (box[k].last_chan+1 > box[k].channels-1) ?
           box[k].channels-1 : box[k].last_chan+1;

    while(1)                                /* insist on a valid channel # */
    {
        fprintf(stderr,"WHICH BOARD CHANNEL IS TO BE USED 0 - %d (%d) ? ",
                box[k].channels-1, def);

        while(1)
        {
            fflush(stdin);
            fgets(buf,sizeof(buf),stdin);

            if(strlen(buf) > 1)
            {
                strtok(buf,"\n");

                if(sscanf(buf,"%d",chan) == 1)
                    break;
            }

            else
            {
                *chan = box[k].last_chan + 1;
                break;
            }
        }

        if((*chan >= 0) && (*chan < box[k].channels))
        {
            box[k].last_chan = *chan;
            break;
        }
    }
} /* get_valid_board() */

/* ***** */
/* Given a driver pointer find the board name in the boards array. */
/* return a pointer to the name. */
/* ***** */
char *get_board_name(float (*driver)())
{
    int i;

    for(i=0;i<MAX_MODULES;i++)
        if(driver == boards[i].driver)
            return(boards[i].name);
}

```

```

    return(NULL);
} /* get_board_name() */

/* ***** */
/* find driver pointer given the board name */
/* ***** */
float (*find_driver_pointer(char *name))()
{
    int i;

    for(i=0;i<MAX_MODULES;i++)
        if(strncmp(name,boards[i].name,8) == 0)
            return(boards[i].driver);

    return(NULL);
} /* find_driver_pointer() */

```

B.1 TEMP.C - Temperature Channel Driver

```
/* ***** */
/* TEMP.C */
/* This module implements thermocouple temperature readings for */
/* DATAVG. It is assumed that a Keithley AIM7 is present. */
/* This pseudo-board supports 16 channels. */
/* */
/* ***** */
/* Written by */
/* R. D. Hardy */
/* Sandia National Laboratories */
/* Department 6117 */
/* April 17, 1992 */
/* */
/* Comments configured for C2LATEX and LATEX*/
/* ***** */
/* On entry if card_slot == -1 call the initialization code to setup */
/* local scaling data and a list of the physical channels to be used. */
/* If card_slot == -2 call the channel data save function. */
/* If card_slot == -3 call the channel restore function. */
/* If card_slot != 0 compute the temperature in degrees C. */
/* ***** */
/* MODIFICATION HISTORY */
/* March 25, 1993 */
/* TEMP.CFG must be in the DATAVG directory. RDH. */
/* */
/* June 25, 1993 */
/* Made extensive changes in init(), restore() and build_tables(). */
/* This module did not properly initialize itself. RDH */
/* */
/* */
/* ***** */

#include "datavg.h"

#define MAX_TC_TAB 5          /* number of thermocouple types */

/* function prototypes */
static void init(int chan);
static int find_board(void);
static void init_error(char *text);
static void save(int chan);
static void restore(int chan);
static struct spline_tab *get_TC_type(void);
static float scale_temp(float TEMP, struct spline_tab *TTAB, int card_slot);
static void build_tables(void);

static int flag = 0;

typedef struct spline_tab
{
    double *xa;                /* Pointer to temp. array */
    double *ya;                /* Pointer to voltage array */
    double *y2a;               /* Pointer to coefficient array */
    int n;                     /* Number of elements in the arrays */
    char type;                 /* Thermocouple type character */
};

static struct spline_tab TC[MAX_TC_TAB];
```



```

/* array of structures holding channel data */
static struct
{
    int chan;                /* real board channel */
    struct spline_tab *table; /* pointer to spline table for this type */
} chanl[16];

int slot;

/* ***** */
/* Main Function. This function dispatches to other functions to */
/* implement a thermocouple reading board for DATAVG. */
/* ***** */
float thermocouple(int chan, int card_slot, int n)
{
    float data;

    switch(card_slot)
    {
        case -1:             /* initialize this channel */
        {
            init(chan);
            return(-1);
        }

        case -2:             /* save configuration for this channel */
        {
            save(chan);
            return(-1);
        }

        case -3:             /* restore configuration for this channel */
        {
            restore(chan);
            return(-1);
        }

        default:             /* read data from this channel */
        {
            /* 100.0 restores the AIM7 gain which is no */
            /* longer passes through read_AIM7() */
            data = read_AIM7(chanl[chan].chan, slot, n) * 100.0;
            return(scale_temp(data, chanl[chan].table, slot));
        }
    }
} /* thermocouple() */

/* ***** */
/* setup this channel. AIM7 must be present. */
/* ***** */
static void init(int chan)
{
    chanl[chan].chan = chan;

```

```

/* Initialize the thermocouple spline tables if not already done */
if(flag == 0)
{
    if((slot = find_board()) == -1)
    {
        init_error("AIM7 board required.");
        return;
    }
    build_tables();
}

/* get the thermocouple type */
chanl[chan].table = get_TC_type();
} /* init() */

/* ***** */
/* locate the AIM7 board and return it's slot number. */
/* ***** */
static int find_board(void)
{
    int i;

    /* search for the aim7 board */
    for(i=1;i<=10;i++)
    {
        if(strncmp(box[i].board,"AIM7",4) == 0)
            break;
    }

    if(i > 10)
    {
        return(-1);
    }

    return(i);
} /* find_board() */

/* ***** */
/* save the configuration data for chan in the file data_file. */
/* ***** */
static void save(int chan)
{
    fprintf(data_file,"%d, %c\n",
            chanl[chan].chan, chanl[chan].table->type);
} /* save() */

/* ***** */
/* restore configuration data for chan from the file data_file. */
/* ***** */
static void restore(int chan)
{
    char type, BUFFER[64];
    int i;

```

```

if(flag == 0)
{
    if((slot = find_board()) == -1)
    {
        init_error("AIM7 board required.");
        return;
    }
    build_tables();          /* build array of data tables */
}

/* get board channel and thermocouple type */
fgets(BUFFER,sizeof(BUFFER),data_file);
sscanf(BUFFER,"%d, %c\n", &chanl[chan].chan, &type);

/* look up the type in the tables */
for(i=0;i<MAX_TC_TAB;i++)
    if(TC[i].type == type)
        break;

if(i == MAX_TC_TAB)
    init_error("Thermocouple type not found in tables");

/* set pointer to table structure */
chanl[chan].table = &TC[i];
} /* restore() */

/* ***** */
/* Print error message and return */
/* ***** */
static void init_error(char *text)
{
    char buf[8];

    clrscr();
    puts(text);
    puts("      Cannot configure for temperature measurement.");
    puts("      Return to continue.");
    fflush(stdin);
    fgets(buf,sizeof(buf),stdin);
} /* init_error() */

/* ***** */
/* function to build the interpolation tables from disk file */
/* ***** */
static void build_tables(void)
{
    FILE *cfg;
    char type;
    int k, n, tc_tab;
    char BUFFER[64];

    if((cfg = fopen("\\\\DATAVG\\THERMO.CFG","r")) == NULL)
    {
        init_error("Thermocouple data file THERMO.CFG not found.");
        return;
    }
}

```

```

/* Process all available thermocouple data tables */
for(tc_tab=0;tc_tab<MAX_TC_TAB;tc_tab++)
{
    fgets(BUFFER,sizeof(BUFFER),cfg);
    if(sscanf(BUFFER,"%c,%d\n",&type,&n) != 2)        /* Size and type */
    {
        break;                                     /* Quit if file exhausted */
    }

    TC[tc_tab].type = toupper(type);    /* Put in structures */
    TC[tc_tab].n = n;

    /* Allocate memory for the tables */
    if((TC[tc_tab].xa = malloc(n * sizeof(double))) == NULL)
    {
        break;                                     /* quit if out of memory */
    }

    if((TC[tc_tab].ya = malloc(n * sizeof(double))) == NULL)
    {
        break;
    }

    if((TC[tc_tab].y2a = malloc(n * sizeof(double))) == NULL)
    {
        break;
    }

    /* Read the tables from disk */
    for(k=0;k<n;k++)
    {
        fgets(BUFFER,sizeof(BUFFER),cfg);
        if(sscanf(BUFFER,"%lf,%lf,%lf\n",
                    TC[tc_tab].xa+k, TC[tc_tab].ya+k, TC[tc_tab].y2a+k) != 3)
            break;
    }
}

/* close configuration file and clear data file name buffer */
fclose(cfg);
flag = 1;
} /* build_tables() */

/* ***** */
/* get valid thermocouple type from user */
/* ***** */
static struct spline_tab *get_TC_type(void)
{
    char types[3*MAX_TC_TAB];
    int n;
    char *ptr = types;
    char BUFFER[16];

    for(n=0;n<MAX_TC_TAB;n++)
    {
        if(TC[n].type == NULL)
            break;
    }
}

```

```

    *ptr++ = TC[n].type;
    *ptr++ = ',';
    *ptr++ = ' ';
}

*(ptr-2) = '\0';          /* terminate the string */
strupr(types);

while(1)
{
    printf("Enter thermocouple type (%s) ? ",types);
    fflush(stdin);
    strupr(fgets(BUFFER,sizeof(BUFFER),stdin));
    ptr = BUFFER;

    while(isspace(*ptr))
        ptr++;             /* remove leading white space */

    for(n=0;n<MAX_TC_TAB;n++)
    {
        /* Thermocouple types */
        if(*ptr == TC[n].type)
            return(&TC[n]);
    }

    fputs("Invalid type\n",stderr);
}

#if __TURBOC__ < 0x400
    return(&TC[n]);
#endif
} /* get_TC_type() */

/* ***** */
/* scale a temperature related voltage into degrees C with correction */
/* for cold junction temperature. Assume use of an AIM7 board. */
/* ***** */
static float scale_temp(float TEMP,struct spline_tab *TTAB, int card_slot)
{
    float offset, comp;
    int i = 0;

    /* get board temperature in offset. 1000.0 corrects for board scaling */
    offset = 1000.0 * read_AIM7(32,card_slot,5);

    /* interpolate to get voltage corresponding to temperature. */
    /* we use linear interpolation because we are within a small range */
    while(TTAB->ya[i] < offset)
        i++;
    comp = ((offset - TTAB->ya[i-1]) / (TTAB->ya[i] - TTAB->ya[i-1]));

    /* offset is now the junction voltage correction */
    offset = ((TTAB->xa[i] - TTAB->xa[i-1]) * comp) + TTAB->xa[i-1];

    /* spline interpolate to get measured temperature */
    return(splint(TTAB->xa,TTAB->ya,TTAB->y2a,TTAB->n,(TEMP + offset)));
} /* scale_temp() */

```

C 500LIB.H

```
/* ***** */
/* 500LIB.H */
/* Prototypes and data declarations for 500LIB.C */
/* */
/* Written by Robert D. Hardy */
/* Sandia National Laboratories */
/* Department 6117 */
/* April 17, 1991 */
/* */
/* Comments configured for C2LATEX and LATEX */
/* ***** */

#include <stdio.h>
#include <dos.h>

/* Timer value structure. This must be allocated by the calling program. */

typedef struct ktime
{
    unsigned int low;
    unsigned int high;
};

/* Function prototypes */
void init_500(unsigned int SEG);
float read_AMM2(int channel, int card_slot, int n);
float read_AIM3(int channel, int card_slot, int n);
float read_AIM7(int channel, int card_slot, int n);
float read_PIN2(int channel, int card_slot, int n);
void reset_PIN2(int channel, int card_slot);
float read_ref(void);
float read_gnd(void);
float scale_AMM2(unsigned long reading);
unsigned int read_ad(void);
float read_DIO1(int channel, int card_slot);
float read_DIM1(int channel, int card_slot);
float write_AOM1(int channel, int card_slot, unsigned int data);
float write_DIO1(int channel, int card_slot, int data);
void set_timer(unsigned int c1, unsigned int c0);
void read_timer(struct ktime *buf);
int read_ID(int card_slot);

#ifdef K500LIB
    #ifdef MAIN
        #define EXTERN
    #else
        #define EXTERN extern
    #endif /* MAIN */

/* define pointers to interface functions. */
```

```

/* AMM2 command structures */
typedef union CommandA
{
    struct
    {
        int chan :4;           /* channel number, 0-7 or 0-15 */
        int mode :1;           /* differential or single ended */
        int local_gain :1;     /* 1x or 10x */
        int ACQ_mode :1;       /* normal or auto */
        int filter :1;         /* 100KHz or 2KHz */
    } f;
    unsigned char cmd;
};

```

```

typedef union CommandB
{
    struct
    {
        int card_slot :4;      /* 0-15 */
        int readmode :1;       /* Status or Data */
        int range :1;          /* +/-10V or 0-10V */
        int global_gain :2;    /* 1x, 2x, 5x or 10x */
    } f;
    unsigned char cmd;
};

```

```

/* Address offsets. */
#define CMD1A 0
#define CMD1B 1
#define CMD1C 26
#define CMD1D 27
#define CMD2A 2
#define CMD2B 3
#define CMD2C 21
#define CMD3A 4
#define CMD3B 5
#define CMD3C 22
#define CMD4A 6
#define CMD4B 7
#define CMD5A 8
#define CMD5B 9
#define CMD6A 10
#define CMD6B 11

#define CMD7A 12
#define CMD7B 13
#define CMD8A 14
#define CMD8B 15
#define CMD9A 16
#define CMD9B 17
#define CMD10A 18
#define CMD10B 19

```

```

/* define some names to be used later. */

```

```

/* Use 128 in a 16MHz Compaq, 512 for a 486/50 */

```

```

#define SIXTEEN      512    /* delay count for 16uS delay in read_ad() */
#define EOC_mask     0x80   /* mask to isolate EOC bit */

/* Global gain command codes. */

#define x1           0      /* Set 1X gain */
#define x2           1      /* Set 2X gain */
#define x5           2      /* Set 5X gain */
#define x10          3      /* Set 10X gain */

/* array of board specific command addresses */
EXTERN unsigned char far *ports[11][4];

/* Fixed addresses on the AMM2 */
EXTERN unsigned char far *SLOT;

EXTERN unsigned char far *AD_LOW;
EXTERN unsigned char far *AD_HIGH;
EXTERN unsigned char far *AD_RECAL;
EXTERN unsigned char far *AD_START;
EXTERN unsigned char far *AD_STAT;

EXTERN unsigned char far *DA_STROBE;

EXTERN unsigned char far *EOC;

/* Fixed addresses on the interface board */
EXTERN unsigned char far *COUNTER0;
EXTERN unsigned char far *COUNTER1;
EXTERN unsigned char far *COUNTER2;
EXTERN unsigned char far *COUNT_CONT;
EXTERN unsigned char far *TIMER_GLOBAL;
EXTERN unsigned char far *TIMER_STAT;

EXTERN unsigned char far *SET_INT;

#undef EXTERN
#endif /* K500LIB */

```


D 500LIB.C

```
/* ***** */
/* 500LIB.c */
/* This file contains the drivers for a Keithley 500 box. */
/* */
/* Written by Robert D. Hardy */
/* Sandia National Laboratories */
/* Department 6117 */
/* April 17, 1991 */
/* */
/* Comments configured for C2LATEX and LATEX */
/* ***** */
/* Modification History: */
/* */
/* May 25, 1993 */
/* Changed AMM2 to use differential inputs conditionally */
/* if K575 is not defined. RDH */
/* */
/* June 25, 1993 */
/* Corrected timing error in read_ad(). Fast machines did */
/* not wait long enough before starting conversion. RDH */
/* */
/* June 25, 1993 */
/* read_AIM7() removes the board gain so readings are in */
/* volts. This allows use of the board for low voltage */
/* inputs. RDH */
/* */
/* ***** */

#define MAIN          /* provide storage for device pointers */
#define K500LIB       /* provide definitions for our data */
#include "500lib.h"

/* Keithley interface segment */
static unsigned int K500_SEG = 0xcff8;

/* AMM2 command buffers */
static union CommandA A;
static union CommandB B;

/* ***** */
/* Function to initialize the interface and set pointers to */
/* interface functions. */
/* ***** */
void init_500(unsigned int SEG)
{
    K500_SEG = SEG;          /* static copy of segment */

    /* Create pointers to all command and status ports. */
    ports[1][0] = MK_FP(K500_SEG, CMD1A);
    ports[1][1] = MK_FP(K500_SEG, CMD1B);
    ports[1][2] = MK_FP(K500_SEG, CMD1C);
    ports[1][3] = MK_FP(K500_SEG, CMD1D);
    ports[2][0] = MK_FP(K500_SEG, CMD2A);
    ports[2][1] = MK_FP(K500_SEG, CMD2B);
    ports[2][2] = MK_FP(K500_SEG, CMD2C);
```

```

ports[3][0] = MK_FP(K500_SEG,CMD3A);
ports[3][1] = MK_FP(K500_SEG,CMD3B);
ports[4][0] = MK_FP(K500_SEG,CMD4A);
ports[4][1] = MK_FP(K500_SEG,CMD4B);
ports[5][0] = MK_FP(K500_SEG,CMD5A);
ports[5][1] = MK_FP(K500_SEG,CMD5B);
ports[6][0] = MK_FP(K500_SEG,CMD6A);
ports[6][1] = MK_FP(K500_SEG,CMD6B);

ports[7][0] = MK_FP(K500_SEG,CMD7A);
ports[7][1] = MK_FP(K500_SEG,CMD7B);
ports[8][0] = MK_FP(K500_SEG,CMD8A);
ports[8][1] = MK_FP(K500_SEG,CMD8B);
ports[9][0] = MK_FP(K500_SEG,CMD9A);
ports[9][1] = MK_FP(K500_SEG,CMD9B);
ports[10][0] = MK_FP(K500_SEG,CMD10A);
ports[10][1] = MK_FP(K500_SEG,CMD10B);

/* Interface board addresses */
COUNTER0 = MK_FP(K500_SEG,0x40);
COUNTER1 = MK_FP(K500_SEG,0x41);
COUNTER2 = MK_FP(K500_SEG,0x42);
COUNT_CONT = MK_FP(K500_SEG,0x43);
TIMER_GLOBAL = MK_FP(K500_SEG,0x60);
TIMER_STAT = MK_FP(K500_SEG,0x61);

SET_INT = MK_FP(K500_SEG,0x63);

AD_LOW = MK_FP(K500_SEG,CMD1A);
AD_HIGH = MK_FP(K500_SEG,CMD1B);
AD_START = MK_FP(K500_SEG,CMD1D);
AD_RECAL = MK_FP(K500_SEG,CMD1C);

EOC = MK_FP(K500_SEG,CMD1D);

*SET_INT = 0xff;          /* Disable all interrupts. */

/* Recalibrate the AMM2 A/D converter */
A.f.chan = 0;             /* set initial mode */
#ifdef K575
A.f.mode = 0;             /* Differential input on AMM2 */
#else
A.f.mode = 1;             /* Single ended input on AMM2 */
#endif
A.f.local_gain = x1;      /* 1X */
A.f.ACQ_mode = 0;         /* Regular acquire */
A.f.filter = 0;           /* 100KHz filter */

B.f.card_slot = 1;        /* AMM2 in slot 1 */
B.f.readmode = 0;         /* read calibrate status */
B.f.range = 1;            /* +/-10V range */
B.f.global_gain = x1;     /* 1X */

*AD_LOW = A.cmd;          /* Send command bytes */
*AD_HIGH = B.cmd;
*AD_RECAL = 0xff;         /* START RECALIBRATION */

```

```

while((*AD_LOW & EOC_mask) >= 0x80); /* Wait for calibration to complete */

B.f.readmode = 1; /* Read AD data mode */

delay(0); /* calibrate the delay routine just in case */
}

/* ***** */
/* Functions to read from analog channels. */
/* ***** */
/* read and average n samples from AMM2 board */
/* ***** */
float read_AMM2(int channel, int card_slot, int n)
{
    int i;
    unsigned long data = 0;

    /* Select the slot to be used. */
    B.f.card_slot = card_slot; /* AMM2 is always in slot 1 */

    /* Select the channel to be used. */
    A.f.chan = channel;

    read_ad(); /* dummy read to clear AD */
    for(i=0; i<n; i++)
        data += read_ad();

    data /= (long)n; /* average reading */
    /* scale into volts */
    return(scale_AMM2(data));
}

/* ***** */
/* read and average n samples from AIM3 board */
/* ***** */
float read_AIM3(int channel, int card_slot, int n)
{
    int i;
    unsigned long data = 0;

    /* Select the slot to be used. */
    B.f.card_slot = card_slot;

    /* Select the channel to be used. */
    *ports[card_slot][0] = channel;

    read_ad(); /* dummy read to clear AD */
    for(i=0; i<n; i++)
        data += read_ad();

    data /= (long)n; /* average reading */
    /* scale into volts */
    return(scale_AMM2(data));
}

```

```

/* ***** */
/* read and average n samples from AIM7 board */
/* ***** */
float read_AIM7(int channel, int card_slot, int n)
{
    int i;
    unsigned long data = 0l;

    /* Select the slot to be used. */
    B.f.card_slot = card_slot;

    /* Select the channel to be used. */
    *ports[card_slot][0] = channel;

    read_ad(); /* dummy read to clear AD */
    for(i=0;i<n;i++)
        data += read_ad();

    data /= (long)n; /* average reading */
    return(scale_AMM2(data) / 100.0); /* scale into volts */
}

/* ***** */
/* Routine to read from a PIM2 board. 16 bit counters. */
/* ***** */
float read_PIM2(int channel, int card_slot, int n)
{
    unsigned int data;

    *ports[card_slot][0] = channel; /* select channel */
    data = *ports[card_slot][0] + (*ports[card_slot][1] << 8);
    return((float)data);
}

/* ***** */
/* Routine to reset a PIM2 board channel */
/* ***** */
void reset_PIM2(int channel, int card_slot)
{
    *ports[card_slot][1] = channel; /* reset channel */
}

/* ***** */
/* Routine to read the ground (0V) reference */
/* ***** */
float read_gnd(void)
{
    unsigned int data;

    B.f.card_slot = 0;
    data = read_ad();
    return((float)data);
}

/* ***** */
/* Routine to read the 10V reference */
/* ***** */
float read_ref(void)
{
    unsigned int data;

```

```

    B.f.card_slot = 13;
    data = read_ad();
    return((float)data);
}

/* ***** */
/* Scale an unsigned integer into a voltage */
/* Assume use of an AMM2 board for reading the */
/* data in integer form. */
/* ***** */
static float scale_AMM2(unsigned long reading)
{
    /* definitions for AMM2 board */
    #define AMM2_offset 10.0
    #define AMM2_counts_per_volt 3276.75

    return(((float)reading / AMM2_counts_per_volt) - AMM2_offset);

    #undef AMM2_offset
    #undef AMM2_counts_per_volt
}

/* ***** */
/* Low level routine used to read any analog */
/* input channel regardless of board. The AMM2 */
/* assumed contains the A/D converter for the */
/* whole box. */
/* ***** */
static unsigned int read_ad(void)
{
    int i;

    /* Send the commands */
    *AD_LOW = A.cmd;
    *AD_HIGH = B.cmd;

    /* delay for settling, must be at least 96 microseconds */
    for(i=0;i<(SIXTEEN*6);) /* define SIXTEEN as needed */
        i++;

    /* Start conversion */
    *AD_START = 0xff;

    /* delay for conversion, must be at least 16 microseconds */
    for(i=0;i<SIXTEEN;) /* define SIXTEEN as needed */
        i++;

    while((*EOC & EOC_mask) == 0x80); /* Wait for EOC */

    /* Read the data */
    return(*AD_LOW + (*AD_HIGH << 8));
}

/* ***** */
/* Function to write to an analog channel. Assumes AOM1. */
/* Data must be scaled into an unsigned int. */
/* ***** */
float write_AOM1(int channel, int card_slot, unsigned int data)
{
    channel <= 1;

```

```

    *ports[card_slot][0] = channel++;
    *ports[card_slot][1] = (data & 255);
    *ports[card_slot][0] = channel;
    *ports[card_slot][1] = (data >> 8);
    *DA_STROBE = 1;

    return(0);
}

/* ***** */
/* Function to read from digital channels. 1 bit channels. */
/* ***** */
float read_DIO1(int channel, int card_slot)
{
    int bit, byte, data;
    unsigned char buf;          /* local copy of port data */

    bit = channel % 8;          /* identify the bit position */
    byte = channel / 8;
    data = (1 << bit);          /* position the data bit for use as a mask */

    /* channels 0-15 are input. channels 16-31 are output only */
    if(byte > 1)
        return(-1.0);

    *ports[card_slot][0] = byte; /* select the port containing the channel */
    buf = *ports[card_slot][1]; /* get the data from the board */

    return((buf & data) ? 0.0 : 1.0);
}

/* ***** */
/* Function to read from digital channels. 1 bit channels */
/* ***** */
float read_DIM1(int channel, int card_slot)
{
    int bit, byte, data;
    unsigned char buf;          /* local copy of port data */

    bit = channel % 8;          /* identify the bit position */
    byte = channel / 8;
    data = (1 << bit);          /* position the data bit for use as a mask */

    buf = *ports[card_slot][byte]; /* get the data from the board */

    return((buf & data) ? 0.0 : 1.0);
}

/* ***** */
/* Function to write to a digital channel. 1 bit channels. */
/* ***** */
float write_DIO1(int channel, int card_slot, int data)
{
    int bit, byte;
    static unsigned char buf[4]; /* local copy of port data */

```

```

    data &= 1;                /* Low bit only */
    bit = channel % 8;        /* identify the bit position */
    byte = channel / 8;
    data <<= bit;             /* position the data bit for use as a mask */

/* channels 0-15 are input. channels 16-31 are output only */
if(byte < 2)
    return(-1);

if(data)
    buf[byte] |= data;        /* set the bit */

else
    buf[byte] &= !data;        /* clear the bit */

*ports[card_slot][0] = byte; /* select the port containing the channel */
*ports[card_slot][1] = buf[byte]; /* send the data to the board */
return(0);                    /* no error */
}

/* ***** */
/* Function to read the board identifications. */
/* Return board ID code or -1 if unable to read the ID */
/* ***** */
int read_ID(int card_slot)
{
    /* int i; */
    /* char far *slot_ad = MK_FP(K500_SEG,0x14); */
    /* char far *start = MK_FP(K500_SEG,0x15); */
    /* char far *get_id = MK_FP(K500_SEG,0x16); */

    /* *slot_ad = card_slot; */
    /* *start = 0xff; */

    /* for(i=0;i<50;i++) */
    /* if(*start & 0x80) */
    /* break; */

    /* return((i == 50)? -1 : (*get_id & 0xff)); */

    return(-1);
} /* read_ID() */

/* ***** */
/* Function to set the timer. */
/* Assumes an 8254 with all counters run in mode 2 cascaded */
/* to roll 2 - 1 - 0. A 1MHz clock into counter 2 is assumed. */
/* This function initializes the counters to the following state */
/* Counter 2 - divide by 1000 to roll over at 1ms intervals */
/* Counter 1 - divide by c1. */
/* Counter 0 - divide by c0. */
/* Where c1 and c0 are user specified constants. */
/* ***** */
void set_timer(unsigned int c1, unsigned int c0)
{
    unsigned int i, l, h;
    struct ktime buf;

```

```

/* set no rollover for quick init. All counters run at 1MHz. */
*TIMER_GLOBAL = (unsigned char)0x0;

i = 1000;
l = i & 0xff;
h = i / 256;

*COUNT_CONT = 0xb4;          /* select counter 2 in mode 2 */
*COUNTER2 = 1;                /* load 1000 to roll at milliseconds */
*COUNTER2 = h;

*COUNT_CONT = 0x74;          /* select counter 1 in mode 2 */
*COUNTER1 = 20;               /* short count to condition counters */
*COUNTER1 = 0;

*COUNT_CONT = 0x34;          /* select counter 0 in mode 2 */
*COUNTER0 = 20;
*COUNTER0 = 0;

/* Wait for counter 0 to count to a low value. */
/* Set 48 bit rollover mode. */
/* Load counter 1 with c1. */
/* Load counter 0 with c0. */

buf.high = 15;
while(buf.high >= 10)
    read_timer(&buf);

*TIMER_GLOBAL = (unsigned char)0x3; /* set 48 bit rollover mode */

i = c1;
l = i & 0xff;
h = i / 256;

*COUNT_CONT = 0x74;          /* select counter 1 in mode 2 */
*COUNTER1 = 1;                /* load with c1 */
*COUNTER1 = h;

i = c0;
l = i & 0xff;
h = i / 256;

*COUNT_CONT = 0x34;          /* select counter 0 in mode 2 */
*COUNTER0 = 1;                /* load with c0 */
*COUNTER0 = h;

/* wait for counter 0 to load */
while(buf.high != c0)
    read_timer(&buf);
}

```



```

/* ***** */
/* Function to read the timer. */
/* */
/* The time is returned in buf as two unsigned integers. */
/* The low integer is in milliseconds and the high one is */
/* in seconds. The seconds counter rolls over at 65536 or less */
/* which amounts to about 18 hours max. If timing is required */
/* for extended periods the using program must adjust for the */
/* rollover in a local seconds counter. */
/* ***** */
void read_timer(struct ktime *buf)
{
    union
    {
        unsigned int j;
        struct
        {
            unsigned char low;
            unsigned char high;
        } i;
    } k;

    *COUNT_CONT = 0xd6;          /* latch counters 0 & 1 for reading */

    /* read low word */
    k.i.low = *COUNTER1;          /* read low byte */
    k.i.high = *COUNTER1;         /* read high byte */
    buf->low = k.j;               /* store result */

    /* read high word */
    k.i.low = *COUNTER0;          /* read low byte */
    k.i.high = *COUNTER0;         /* read high byte */
    buf->high = k.j;              /* store result */
}

```

E SRBGRAPH.H

```
/* ***** */
/* SRBGRAPH.H */
/* */
/* This file defines the functions and data structures for a windowing */
/* graphics package written by Steve R. Brown and edited by */
/* Robert D. Hardy Sandia National Laboratories Dept. 6117. */
/* */
/* Comments configured for C2LATEX and LATEX*/
/* ***** */

#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <conio.h>
#include <math.h>
#include <graphics.h>

#define MAXWINDOWS 8          /* Number of windows allowed. */

/* global data, only visible in the graphics library */
#ifndef GRAPH_LIB

#ifdef DATA
#define EXTERN
const float MARGIN = 0.1, HEADSIZE = 0.05, TICKSIZE = 0.01;
#else
#define EXTERN extern
extern const float MARGIN, HEADSIZE, TICKSIZE;
#endif

#define HEADER_LEN 40          /* Length of window header line. */
#define TRUE 1
#define FALSE 0
#define CLIPON 1
#define CLIPOFF 0

struct WINDOWINFO
{
    int    SX1, SY1, SX2, SY2;    /* screen coordinates */
    float  UX1, UY1, UX2, UY2;    /* user coordinates */
    char   HEADER[HEADER_LEN];
    int    DRAWN;
    int    Xstart, Ystart;        /* line starting points */
    float  AX, AY, BY;
    int    X1WND, X2WND, Y1WND, Y2WND, SYMBOLSIZE;
};

EXTERN struct WINDOWINFO WIND[MAXWINDOWS];

EXTERN int

    GRAPHDRIVER,    /* The graphics device driver */
    GRAPHMODE,      /* The graphics mode value */
    MAXX, MAXY,     /* The maximum resolution of the screen */
    ERRORCODE,      /* Reports any graphics errors */
    MAXCOLOR,       /* The maximum color value available */
```

```

XCURSOR, YCURSOR,
MAXWINDOW, INDEX,
FIRSTCURSOR,
BACKGROUND_COLOR,
WINDOW_COLOR,
AXIS_COLOR,
DRAW_COLOR,
Our_Font, Hm, Hd, Vm, Vd, Tw, Th; /* text scaling and font */

EXTERN void *CURSOR;
void srbgraph_make_near_string(char *header, char far *hdr, int n);
#endif /* GRAPH_LIB */

/* FUNCTION PROTOTYPES */
void far data(void);
void far error(char far *string);
void far open_graph(void);
void far draw_border(int SXmin, int SYmin, int SXmax, int SYmax,
                    char far *header);

void far define_window(int window, int SXmin, int SYmin,
                    int SXmax, int SYmax,
                    float UXmin, float UYmin,
                    float UXmax, float UYmax);

void far select_window(int window);
void far define_header(int window, char far *hdr);
void far coord_display(float xc, float yc, char far *c);
void far erase_coord_display(void);
void far reset_windows(void);
void far erase_window(int window);

int far window_x(float x);
int far window_y(float y);

void far draw_axes(int window, int ticksx, int ticksy,
                    char far *name_x, char far *name_y);

void far draw_point(float xr, float yr);
void far draw_line(float UXmin, float UYmin, float UXmax, float UYmax);
void far draw_line_to(float xr, float yr);

void far move_to(float xr, float yr);

void far draw_square(float xr, float yr);
void far draw_x(float xr, float yr);
void far draw_triangle(float xr, float yr);
void far draw_diamond(float xr, float yr);
void far draw_circle(float xr, float yr);
void far draw_cross(float xr, float yr);
void far draw_star(float xr, float yr);

void far make_cursor(void);
void far put_cursor(float x, float y);
void far erase_cursor(void);
void far free_cursor(void);

void far menu_bar(int top, int n, char far *text[]);

```

F SRBGRAPH Composite Source

```
/* ***** */
/* SRBGRAPH.C */
/**/
/* This file contains the first part of a windowing graphics package */
/* written by Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/**/
/* comments configured for C2LATEX and LATEX */
/* ***** */
#define GRAPH_LIB          /* provides the data definitions */
#define DATA              /* declares data */
#include "srbgraph.h"

/* ***** */
/* Initialize graphics and report any errors that may occur */
/* ***** */
void far open_graph(void)
{
    registerfarbgidriver(CGA_driver_far);
    registerfarbgidriver(EGAVGA_driver_far);
    registerfarbgidriver(Herc_driver_far);
    registerfarbgifont(small_font_far);

    while(1)
    {
        GRAPHMODE = IBM8514HI;
        GRAPHDRIVER = IBM8514;
        initgraph(&GRAPHDRIVER, &GRAPHMODE, "");

        if((ERRORCODE = graphresult()) == grOk)
        {
            Our_Font = SMALL_FONT;
            Hm = 2, Hd = 1, Vm = 2, Vd = 1;
            BACKGROUNDCOLOR = BLACK;
            WINDOWCOLOR      = LIGHTBLUE;
            AXISCOLOR        = YELLOW;
            DRAWCOLOR        = WHITE;
            break;
        }

        GRAPHMODE = 0;
        GRAPHDRIVER = DETECT;
        initgraph(&GRAPHDRIVER, &GRAPHMODE, "");

        if((ERRORCODE = graphresult()) == grOk)
        {
            Our_Font = DEFAULT_FONT;
            Hm = 1, Hd = 1, Vm = 1, Vd = 1;
            if((GRAPHDRIVER == VGA) || (GRAPHDRIVER == EGA))
            {
                BACKGROUNDCOLOR = BLACK;
                WINDOWCOLOR      = BLUE;
                AXISCOLOR        = LIGHTRED;
                DRAWCOLOR        = WHITE;
            }
        }
    }
}
```

```

    else
    {
        BACKGROUND_COLOR = BLACK;
        WINDOW_COLOR      = BLACK;
        AXIS_COLOR        = WHITE;
        DRAW_COLOR        = WHITE;
    }
    break;
}

printf(" BGI graphics system error: %s\n", grapherrormsg(ERRORCODE));
closegraph();
exit(1);
}

MAX_COLOR = getmaxcolor();    /* Read maximum number of colors*/
MAX_X = getmaxx();
MAX_Y = getmaxy();
MAX_WINDOW = 0;

setusercharsize(Hm,Hd,Vm,Vd);
Th = textheight("W");
Tw = textwidth("W");
}

/* ***** */
void far srbgraph_make_near_string(char *header, char far *hdr, int n)
{
    int i;

    for(i=0; i<n-1; i++)
        if((header[i] = *hdr++) == NULL)
            break;
    header[i] = '\0';
}

```

F.1 DEFINE.C

```

/* ***** */
/* DEFINE.C */
/* */
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept 6117. */
/* */
/* comments configured for C2LATEX and LATEX */
/* ***** */
#define GRAPH_LIB          /* provides the data definitions */
#include "srbgraph.h"

/* ***** */
/* fill in the WINDINFO structure for this window if all parameters */
/* are valid */
/* ***** */
void far define_window(int window,
                      int SXmin, int SYmin, int SXmax, int SYmax,
                      float UXmin, float UYmin, float UXmax, float UYmax)
{

```

```

float Xconst = (float)MAXX / 100.0;
float MaxY = (float)MAXY;
float Yconst = (float)MAXY / 100.0;

if((window < 0) || (window > MAXWINDOWS))
    error("define_window, Invalid window number");

/* range check input values */
if((SXmin < SXmax) &&          /* min values must be ; max values */
    (SYmin < SYmax) &&
    (SXmin >= 0) &&            /* window position must be within screen */
    (SXmax <= 100) &&
    (SYmin >= 0) &&
    (SYmax <= 100) &&
    (UXmin < UXmax) &&
    (UYmin < UYmax))
{
    WIND[window].HEADER[0] = '\0';    /* clear header storage */
    WIND[window].DRAWN = FALSE;      /* window not drawn */

/* origin: lower left corner */
    WIND[window].SX1 = (int)((float)SXmin * Xconst);
    WIND[window].SY1 = (int)(MaxY - ((float)SYmax * Yconst));
    WIND[window].UX1 = UXmin;
    WIND[window].UY1 = UYmin;

/* origin: upper right corner */
    WIND[window].SX2 = (int)((float)SXmax * Xconst);
    WIND[window].SY2 = (int)(MaxY - ((float)SYmin * Yconst));
    WIND[window].UX2 = UXmax;
    WIND[window].UY2 = UYmax;

    if (window > MAXWINDOW)
    {
        MAXWINDOW = window;          /* count windows defined */
    }
}

else /* invalid input data */
    error("define_window, bad data provided");
}

```

F.2 DEF_DHR.C

```

/* ***** */
/* DEF_HDR.C */
/* */
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/* */
/* comments configured for C2LATEX and LATEX */
/* ***** */
#define GRAPH_LIB          /* provides the data definitions */
#include "srbgraph.h"

```

```

/* ***** */
/* place the header text in the generic structure */
/* ***** */
void far define_header(int window, char far *hdr)
{
    char header[HEADER_LEN];

    if (window <= MAXWINDOW)
    {
        srbgraph_make_near_string(header,hdr,sizeof(header));
        strncpy(WIND[window].HEADER,header,HEADER_LEN-1);
    }
}

```

F.3 DRAWAXIS.C

```

/* ***** */
/* DRAWAXIS.C */
/* */
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/* */
/* Comments configured for C2LATEX and LATEX */
/* ***** */
#define GRAPH_LIB          /* provides the data definitions */
#include "srbgraph.h"

static void far draw_x_axis(int number_of_ticks, char far *name);
static void far draw_y_axis(int number_of_ticks, char far *name);
static void scale_axes(char **text, int n, float MIN, float MAX);
static void make_X_labels(int number_of_ticks);
static void make_Y_labels(int number_of_ticks);

static char s[HEADER_LEN];
static float dx, dy, delta;
static int ticks;
static char *Xptrs[25];          /* pointers used in axis labeling routines */
static char *Yptrs[25];

/* ***** */
/* draw the X-axis in the current window */
/* The window to use must be selected before calling this routine */
/* ***** */
static void far draw_x_axis(int number_of_ticks, char far *name)
{
    int text_pos;
    int line_height = Th+3;

    setviewport(WIND[INDEX].X1WND, WIND[INDEX].Y1WND,
                WIND[INDEX].X2WND, WIND[INDEX].Y2WND, CLIPOFF);

    setcolor(AXISCOLOR);

    /* lower line */
    line(window_x(WIND[INDEX].UX1),window_y(WIND[INDEX].UY1),
          window_x(WIND[INDEX].UX2),window_y(WIND[INDEX].UY1));
}

```

```

/* upper line */
line(window_x(WIND[INDEX].UX1),window_y(WIND[INDEX].UY2),
      window_x(WIND[INDEX].UX2),window_y(WIND[INDEX].UY2));

/* graticule spacing */
delta = (WIND[INDEX].UX2 - WIND[INDEX].UX1) / (float)(number_of_ticks-1);

/* vertical graticule lines */
setlinestyle(DOTTED_LINE,0,NORM_WIDTH);

for (ticks = 1; ticks < (number_of_ticks-1); ticks++)
{
    dx = (float)ticks * delta;
    line(window_x(WIND[INDEX].UX1+dx),window_y(WIND[INDEX].UY1),
          window_x(WIND[INDEX].UX1+dx),window_y(WIND[INDEX].UY2));
}

/* label ticks, text has already been generated */
setlinestyle(SOLID_LINE,0,NORM_WIDTH);
settextjustify(CENTER_TEXT,CENTER_TEXT);
settextstyle(Our_Font,HORIZ_DIR,0);

/* line position for text */
text_pos = (window_y(WIND[INDEX].UY1) + Th + 3);

for (ticks = 0; ticks <= (number_of_ticks-1); ticks++)
{
    dx = (float)ticks * delta;
    outtextxy(window_x(WIND[INDEX].UX1+dx),text_pos,Xptrs[ticks]);
    free(Xptrs[ticks]);      /* return storage */
}

text_pos += line_height;

outtextxy(window_x(WIND[INDEX].UX1+dx),text_pos,Xptrs[ticks]);
free(Xptrs[ticks]);

/* label axis */
setviewport(0, 0, MAXX, MAXY, CLIPOFF);
settextjustify(CENTER_TEXT,BOTTOM_TEXT);
srbgraph_make_near_string(s,name,sizeof(s));
outtextxy(((WIND[INDEX].X2WND - WIND[INDEX].X1WND) / 2) + WIND[INDEX].X1WND,
          (WIND[INDEX].SY2 - 2),s);

setcolor(DRAWCOLOR);
setviewport(WIND[INDEX].X1WND, WIND[INDEX].Y1WND,
            WIND[INDEX].X2WND, WIND[INDEX].Y2WND, CLIPON);
}

/* ***** */
/* draw the Y-axis in the current window */
/* The window to use must be selected before calling this routine */
/* ***** */
static void far draw_y_axis(int number_of_ticks, char far *name)
{
    int text_pos;
    int line_height = Th + 3;

```



```

setviewport(WIND[INDEX].X1WND, WIND[INDEX].Y1WND,
            WIND[INDEX].X2WND, WIND[INDEX].Y2WND, CLIPOFF);

setcolor(AXISCOLOR);

/* left line */
line(window_x(WIND[INDEX].UX1),window_y(WIND[INDEX].UY1),
      window_x(WIND[INDEX].UX1),window_y(WIND[INDEX].UY2));

/* right line */
line(window_x(WIND[INDEX].UX2),window_y(WIND[INDEX].UY1),
      window_x(WIND[INDEX].UX2),window_y(WIND[INDEX].UY2));

/* graticule spacing */
delta = (WIND[INDEX].UY2 - WIND[INDEX].UY1) / (float)(number_of_ticks-1);

/* horizontal graticule lines */
setlinestyle(DOTTED_LINE,0,NORM_WIDTH);

for (ticks = 1; ticks < (number_of_ticks-1); ticks++)
{
    dy = (float)ticks * delta;
    line(window_x(WIND[INDEX].UX1),window_y(WIND[INDEX].UY1+dy),
          window_x(WIND[INDEX].UX2),window_y(WIND[INDEX].UY1+dy));
}

/* label ticks, text has already been generated */
setlinestyle(SOLID_LINE,0,NORM_WIDTH);
settextstyle(Our_Font,HORIZ_DIR,0);
settextjustify(RIGHT_TEXT,CENTER_TEXT);

/* line position for text */
text_pos = (window_x(WIND[INDEX].UX1) - Tw);

for (ticks = 0; ticks <= (number_of_ticks-1); ticks++)
{
    dy = (float)ticks * delta;
    outtextxy(text_pos,window_y(WIND[INDEX].UY1+dy),Yptrs[ticks]);
    free(Yptrs[ticks]);          /* return storage */
}

/* put exponent on screen */
outtextxy(text_pos, (window_y(WIND[INDEX].UY2)-line_height),
          Yptrs[ticks]);

free(Yptrs[ticks]);

/* label axis */
setviewport(0, 0, MAXX, MAXY, CLIPOFF);
settextstyle(Our_Font,VERT_DIR,0);
settextjustify(RIGHT_TEXT,CENTER_TEXT);

srbgraph_make_near_string(s,name,sizeof(s));
outtextxy((WIND[INDEX].SX1 + Th +3),
          (((WIND[INDEX].Y2WND - WIND[INDEX].Y1WND) / 2) + WIND[INDEX].Y1WND),s);

```

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```

    settextstyle(Our_Font,HORIZ_DIR,0);
    setcolor(DRAWCOLOR);
    setviewport(WIND[INDEX].X1WND, WIND[INDEX].Y1WND,
                WIND[INDEX].X2WND, WIND[INDEX].Y2WND, CLIPON);
}

/* ***** */
/* draw both axes in the selected window */
/* ***** */
void far draw_axes(int window, int ticksx, int ticksy,
                  char far *namex, char far *namey)
{
    select_window(window);

    if (INDEX > MAXWINDOW)
        error("draw_axes, undefined window");

    make_X_labels(ticksx);          /* make labels and reset plot limits */
    make_Y_labels(ticksy);

    draw_x_axis(ticksx,namex);      /* draw axis using predefined labels */
    draw_y_axis(ticksy,namey);

    draw_cross(0.0,0.0);            /* place a marker at 0,0 */
}

/* ***** */
/* make a set of X axis labels and reset the plot limits. This must */
/* be done before the axes are drawn. */
/* ***** */
static void make_X_labels(int number_of_ticks)
{
    int i;

    /* allocate label storage */
    for(i=0;i<=number_of_ticks;i++)
    {
        Xptrs[i] = malloc(16);
    }

    /* create label text */
    scale_axes(Xptrs,number_of_ticks,WIND[INDEX].UX1,WIND[INDEX].UX2);
}

/* ***** */
/* make a set of Y axis labels and reset the plot limits. This must */
/* be done before the axes are drawn. */
/* ***** */
static void make_Y_labels(int number_of_ticks)
{
    int i;

    /* allocate label storage */
    for(i=0;i<=number_of_ticks;i++)
    {
        Yptrs[i] = malloc(16);
    }
}

```

```

/* create label text */
scale_axes(Yptrs,number_of_ticks,WIND[INDEX].UY1,WIND[INDEX].UY2);
}

/* ***** */
/* This function creates an array of tick labels in text[]. text[] */
/* must be at least n+1 items long. The XAxis labels are in */
/* text[0] - text[n-1]. The exponent string is in text[n]. */
/* ***** */
static void scale_axes(char **text, int n, float MIN, float MAX)
{
    int i;
    double L;
    float step, start;
    float power;

/* scale from mid point */
    start = log10( fabs( ((double)MAX - (double)MIN) / 2.0 ));

    if(start < 0.0)
        start--;

    L = pow10((int)start);          /* Scale factor */
    power = log10(L);
    start = MIN / L;                /* make starting values */
    step = (MAX - MIN) / ((n-1) * L);

    for(i=0;i<n;i++)                /* make axis labels */
    {
        sprintf(text[i], "%.2f", (start+(i*step)));
    }

    sprintf(text[n], "E%+3d", (int)power); /* make exponent string */
}

```

F.4 DRAW_B.C

```

/* ***** */
/* DRAW_B.C */
/* */
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/* */
/* comments configured for C2LATEX and LATEX */
/* ***** */
#define GRAPH_LIB          /* provides the data definitions */
#include "srbgraph.h"

/* ***** */
/* draw a border and put in the header text */
/* The window to use must be selected before calling this routine */
/* ***** */
void far draw_border(int SXmin, int SYmin, int SXmax, int SYmax,
                    char far *header)
{
    int size = MAXY * HEADSIZE;
    int scale;

```

```

setfillstyle(SOLID_FILL,WINDOWCOLOR);
bar3d(0,size,SXmax-SXmin,SYmax-SYmin,0,FALSE);

setfillstyle(SOLID_FILL,BACKGROUNDCOLOR);
bar3d(0,0,SXmax-SXmin,size,0,FALSE);

if (header != "")
{
    scale = size / Th;
    setusercharsize(scale,1,scale,1);    /* scale to fit space */
    setttextjustify(CENTER_TEXT,CENTER_TEXT);
    setttextstyle(Our_Font,HORIZ_DIR,0);
    outtextxy((SXmax-SXmin) / 2, size / 2, header);
    setusercharsize(Hm,Hd,Vm,Vd);        /* restore text scaling */
}
}

```

F .5 MENU_BAR.C

```

/* ***** */
/* MENU_BAR.C */
/* */
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/* */
/* comments configured for C2LATEX and LATEX */
/* ***** */

/* ***** */
/* draw a menu bar at the bottom of the screen. the bar is divided */
/* into ten boxes across the screen width. the bar always starts at */
/* the bottom of the screen. top defines the height of the bar in */
/* percent of screen height. if n < 10 there are two rows of boxes */
/* in height screen area. text from the array text[] is placed in */
/* the boxes. */
/* ***** */

#define GRAPH_LIB          /* provides the data definitions */
#include "srbgraph.h"

/* ***** */
/* make a box and display the X,Y values */
/* ***** */

void far menu_bar(int top, int n, char far *text[])
{
    int i;
    float l, r, t, b;
    float deltaX, deltaY;
    float height;

    height = (float)MAXY / 100.0 * (float)top;

    deltaX = (float)MAXX / 10.0;          /* set intervals for boxes */
    deltaY = (n > 10)? height / 2.0 : height;

    l = 0;                                /* init box positions */
    r = deltaX;
    b = MAXY;                              /* BGI top is 0 */
    t = b - deltaY;                       /* our system is inverted */

```

```

setfillstyle(SOLID_FILL,BACKGROUND_COLOR);
settextjustify(CENTER_TEXT,CENTER_TEXT);
setviewport(0,0,MAXX,MAXY,CLIPON);

draw boxes and fill in text

for(i=0;i<n;i++)
{
    bar3d(l,t,r,b,0,FALSE);
    outtextxy((int)(l + (deltaX / 2)), (int)(t + (deltaY / 2)), text[i]);
    l = r;                                /* set next left and right ends */
    r = (r + deltaX);

    if(i == 9)
    {
        l = 0;                            /* set next left and right ends */
        r = deltaX;
        b = t;                            /* set next top and bottom */
        t = (t - deltaY);
    }
}
}

```

F.6 LINE.C

```

/* ***** */
/* LINE.C */
/* */
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/* */
/* comments configured for C2LATEX and LATEX */
/* ***** */
#define GRAPH_LIB          /* provides the data definitions */
#include "srbggraph.h"

/* ***** */
/* draw a line between the specified points in the current window */
/* the current position is not updated */
/* ***** */
void far draw_line(float UXmin, float UYmin, float UXmax, float UYmax)
{
    line(window_x(UXmin),window_y(UYmin),window_x(UXmax),window_y(UYmax));
}

```

F.7 LINE_TO.C

```

/* ***** */
/* LINE_TO.C */
/* */
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/* */
/* comments configured for C2LATEX and LATEX */
/* ***** */
#define GRAPH_LIB          /* provides the data definitions */
#include "srbggraph.h"

```

```

/* ***** */
/* draw a line to the specified point in the current window */
/* the current position is updated */
/* ***** */
void far draw_line_to(float xr, float yr)
{
    int Xs, Ys;

    Xs = window_x(xr);
    Ys = window_y(yr);

    line(WIND[INDEX].Xstart, WIND[INDEX].Ystart, Xs, Ys);

    WIND[INDEX].Xstart = Xs;
    WIND[INDEX].Ystart = Ys;
}

```

F.8 MOVETO.C

```

/* ***** */
/* MOVETO.C */
/* */
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/* */
/* comments configured for C2LATEX and LATEX */
/* ***** */
#define GRAPH_LIB          /* provides the data definitions */
#include "srbgraph.h"

/* ***** */
/* place the current position at xr, yr */
/* used before starting a line plot */
/* ***** */
void far move_to(float xr, float yr)
{
    WIND[INDEX].Xstart = window_x(xr);
    WIND[INDEX].Ystart = window_y(yr);
}

```

F.9 POINT.C

```

/* ***** */
/* POINT.C */
/* */
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/* */
/* comments configured for C2LATEX and LATEX */
/* ***** */
#define GRAPH_LIB          /* provides the data definitions */
#include "srbgraph.h"

```



```

/* ***** */
/* put a point in the current window */
/* ***** */
void far draw_point(float xr, float yr)
{
    putpixel(window_x(xr), window_y(yr), DRAWCOLOR);
}

```

F.10 PUT_CORD.C

```

/* ***** */
/* PUT_CORD.C */
/* */
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/* */
/* comments configured for C2LATEX and LATEX */
/* ***** */
/* coordinate display routines for SRBGRAPH library */
#define GRAPH_LIB /* provides the data definitions */
#include "srbgraph.h"

/* ***** */
/* make a box and display the X,Y values */
/* ***** */
void far coord_display(float xc, float yc, char far *c)
{
    char sx[40], sy[40];
    int size;

    size = MAXY * HEADSIZE;
    setviewport(WIND[INDEX].SX1, WIND[INDEX].SY1,
                WIND[INDEX].SX2, WIND[INDEX].SY2, CLIPON);
    setfillstyle(SOLID_FILL, BACKGROUND_COLOR);
    bar3d((WIND[INDEX].SX2 - WIND[INDEX].SX1) / 2, size+2,
          WIND[INDEX].SX2 - WIND[INDEX].SX1 - 2, 2*size, 0, FALSE);

    gcvt(xc, 5, sx);
    gcvt(yc, 5, sy);
    strcat(sx, " ");
    strcat(sy, sy);

    settextjustify(LEFT_TEXT, CENTER_TEXT);
    outtextxy((WIND[INDEX].SX2 - WIND[INDEX].SX1) / 2 + 2, 1.5*size+2, c);

    settextjustify(CENTER_TEXT, CENTER_TEXT);
    outtextxy(3 * (WIND[INDEX].SX2 - WIND[INDEX].SX1) / 4, 1.5*size+2, sx);

    setviewport(WIND[INDEX].X1WND, WIND[INDEX].Y1WND,
                WIND[INDEX].X2WND, WIND[INDEX].Y2WND, CLIPON);
}

```

F .11 CLR_CORD.C

```
/* ***** */
/* CLR_CORD.C */
/* /* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/* */
/* comments configured for C2LATEX and LATEX*/
/* ***** */
#define GRAPH_LIB          /* provides the data definitions */
#include "srbgraph.h"

/* ***** */
/* remove the coordinate display box */
/* ***** */
void far erase_coord_display()
{
    int size;

    size = MAXY * HEADSIZE;

    setviewport(WIND[INDEX].SX1, WIND[INDEX].SY1,
                WIND[INDEX].SX2, WIND[INDEX].SY2, CLIPON);
    setfillstyle(SOLID_FILL, WINDOWCOLOR);
    bar((WIND[INDEX].SX2 - WIND[INDEX].SX1) / 2, size+2,
        WIND[INDEX].SX2 - WIND[INDEX].SX1 - 2, 2*size);

    setviewport(WIND[INDEX].X1WND, WIND[INDEX].Y1WND,
                WIND[INDEX].X2WND, WIND[INDEX].Y2WND, CLIPON);
}
```

F .12 MAKECURS.C

```
/* ***** */
/* MAKECURS.C */
/* */
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/* */
/* comments configured for C2LATEX and LATEX*/
/* ***** */

cursor routines for SRBGRAPH library

#define GRAPH_LIB          /* provides the data definitions */
#include "srbgraph.h"

/* ***** */
/* draw a cursor mark in the current window */
/* ***** */
void far make_cursor(void)
{
    int ulx, uly;
    int lrx, lry;
    int cursorsize;
    int scale;
```

```

/* draw_cursor */
XCURSOR = 10;
YCURSOR = 10;
scale = 5;
line(XCURSOR-scale, YCURSOR, XCURSOR+scale, YCURSOR);
line(XCURSOR, YCURSOR-scale, XCURSOR, YCURSOR+scale);

/* Read cursor image */
ulx = XCURSOR-scale;
uly = YCURSOR-scale;
lrx = XCURSOR+scale;
lry = XCURSOR+scale;

cursorsize = imagesize(ulx, uly, lrx, lry);
CURSOR = malloc(cursorsize);
getimage(ulx, uly, lrx, lry, CURSOR);

/* erase old */
putimage(XCURSOR-scale, YCURSOR-scale, CURSOR, XOR_PUT);
FIRSTCURSOR = TRUE;
}

```

F.13 PUT_CURS.C

```

/* ***** */
/* PUT_CURS.C */
/* */
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/* */
/* comments configured for C2LATEX and LATEX */
/* ***** */
#define GRAPH_LIB          /* provides the data definitions */
#include "srbgraph.h"

/* ***** */
/* position the active cursor in the current window */
/* ***** */
void far put_cursor(float x, float y)
{
    int scale = 5;

    if (FIRSTCURSOR == FALSE)    /* erase old cursor */
        putimage(XCURSOR-scale, YCURSOR-scale, CURSOR, XOR_PUT);

    FIRSTCURSOR = FALSE;

    XCURSOR = window_x(x);
    YCURSOR = window_y(y);

    /* draw new cursor */
    putimage(XCURSOR-scale, YCURSOR-scale, CURSOR, XOR_PUT);
}

```

F .14 CLR_CURS.C

```
/* **** */
/* CLR_CURS.C */
/* /* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/* */
/* comments configured for C2LATEX and LATEX*/
/* **** */
#define GRAPH_LIB          /* provides the data definitions */
#include "srbgraph.h"

/* **** */
void far erase_cursor()
{
    int scale = 5;

    putimage(XCURSOR-scale, YCURSOR-scale, CURSOR, XOR_PUT);
    FIRSTCURSOR = TRUE;
}
```

F .15 RM_CURS.C

```
/* **** */
/* RM_CURS.C */
/* */
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/* */
/* comments configured for C2LATEX and LATEX*/
/* **** */
#define GRAPH_LIB          /* provides the data definitions */
#include "srbgraph.h"

/* **** */
void far free_cursor()
{
    free(CURSOR);
}
```

F .16 SELECT.C

```
/* **** */
/* SELECT.C */
/* */
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/* */
/* comments configured for C2LATEX and LATEX*/
/* **** */
#define GRAPH_LIB          /* provides the data definitions */
#include "srbgraph.h"
```

```

/* ***** */
/* set the window for future operations and draw it if not already */
/* done the plot routines use a generic WINDINFO structure filled in */
/* by select_window() */
/* ***** */
void far select_window(int window)
{
    char msg[64];

    if (window <= MAXWINDOW)
    {
        INDEX = window;          /* current window number for other routines */
        if(WIND[INDEX].DRAWN == FALSE)
        {
            setviewport(WIND[INDEX].SX1,      /* draw the window */
                        WIND[INDEX].SY1,
                        WIND[INDEX].SX2,
                        WIND[INDEX].SY2,
                        CLIPON);

            draw_border(WIND[INDEX].SX1,
                        WIND[INDEX].SY1,
                        WIND[INDEX].SX2,
                        WIND[INDEX].SY2,
                        WIND[INDEX].HEADER);

            /* window now drawn, check for zero length user axes */

            if((WIND[INDEX].UX1 == WIND[INDEX].UX2) ||
               (WIND[INDEX].UY1 == WIND[INDEX].UY2))
            {
                /* default values if either axis has no length */
                /* this should not be the case */

                WIND[INDEX].X1WND = WIND[INDEX].SX1;
                WIND[INDEX].X2WND = WIND[INDEX].SX2;
                WIND[INDEX].Y1WND = WIND[INDEX].SY1 + MAXY * HEADSIZE;
                WIND[INDEX].Y2WND = WIND[INDEX].SY2;

                WIND[INDEX].AX = 1.0;
                WIND[INDEX].AY = 1.0;

                WIND[INDEX].BY = WIND[INDEX].Y2WND - WIND[INDEX].Y1WND;
                WIND[INDEX].SYMBOLSIZE = (WIND[INDEX].SX2 - WIND[INDEX].SX1) * TICKSIZE / 2;
            }

            else          /* user axes have length */
            {
                /* compute graticule area */
                /* leave window_size*2*MARGIN on left */
                WIND[INDEX].X1WND = WIND[INDEX].SX1 +
                                    (WIND[INDEX].SX2 - WIND[INDEX].SX1)
                                    * 2 * MARGIN;

                /* leave window_size*MARGIN on right */
                WIND[INDEX].X2WND = WIND[INDEX].SX2 -
                                    (WIND[INDEX].SX2 - WIND[INDEX].SX1) * MARGIN;
            }
        }
    }
}

```

```

/* leave window_size*MARGIN + HEADSIZE on top */
WIND[INDEX].Y1WND = WIND[INDEX].SY1 + ((WIND[INDEX].SY2 -
WIND[INDEX].SY1) * MARGIN) + (MAXY * HEADSIZE);

/* leave window_size*1.5*MARGIN on bottom */
WIND[INDEX].Y2WND = WIND[INDEX].SY2 -
(WIND[INDEX].SY2 - WIND[INDEX].SY1)
* 1.5 * MARGIN;

/* X scale factor */
WIND[INDEX].AX = ((WIND[INDEX].X2WND - WIND[INDEX].X1WND) /
(WIND[INDEX].UX2 - WIND[INDEX].UX1));

/* Y scale factor */
WIND[INDEX].AY = ((WIND[INDEX].Y2WND - WIND[INDEX].Y1WND) /
(WIND[INDEX].UY2 - WIND[INDEX].UY1));

/* Y offset, used to invert Y-AXIS */
WIND[INDEX].BY = (WIND[INDEX].Y2WND - WIND[INDEX].Y1WND);

/* SYMBOLSIZE is used to draw markers */
WIND[INDEX].SYMBOLSIZE = (WIND[INDEX].SX2 - WIND[INDEX].SX1)
* TICKSIZE;
}
WIND[INDEX].DRAWN = TRUE;
}

setviewport(WIND[INDEX].X1WND, WIND[INDEX].Y1WND,
WIND[INDEX].X2WND, WIND[INDEX].Y2WND, CLIPON);
}

else
{
    sprintf(msg,"select_window, undefined window %d.\n",window);
    error(msg);
}
}

```

F.17 RESET_W.C

```

/* ***** */
/* RESET_W.C */
/* */
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/* */
/* comments configured for C2LATEX and LATEX */
/* ***** */
#define GRAPH_LIB /* provides the data definitions */
#include "arbgraph.h"

/* ***** */
/* all windows use the whole screen */
/* ***** */
void far reset_windows()
{
    int window;

```

```

for (window = 0; window < MAXWINDOWS; window++)
{
    define_window(window, 0, 0, 100, 100, 0, 0, 1, 1);
    WIND[window].Xstart = 0;
    WIND[window].Ystart = 0;
}

select_window(0);
}

```

F .18 ERASE_W.C

```

/* ***** */
/* ERASE_W.C */
/* */
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/* */
/* Comments configured for C2LATEX and LATEX */
/* ***** */
#define GRAPH_LIB          /* provides the data definitions */
#include "srbgraph.h"

/* ***** */
/* clear the selected window area */
/* ***** */
void far erase_window(int window)
{
    if (window <= MAXWINDOW)
    {
        WIND[window].DRAWN = FALSE;
        setviewport(0, 0, WIND[window].SX2, WIND[window].SY2, CLIPON);
        setfillstyle(SOLID_FILL, BACKGROUND_COLOR);
        bar(WIND[window].SX1, WIND[window].SY1,
            WIND[window].SX2, WIND[window].SY2);
    }

    else
        error("erase_window, undefined window");
}

```

F .19 ERROR.C

```

/* ***** */
/* ERROR.C */
/* */
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/* */
/* comments configured for C2LATEX and LATEX */
/* ***** */
#define GRAPH_LIB          /* provides the data definitions */
#include "srbgraph.h"

```

```

/* ***** */
void far error(char far *string)
{
    closegraph();
    printf("graphics module error: %s\n",string);
    exit(1);
}

```

F.20 SCALE.C

```

/* ***** */
/* SCALE.C */
/* */
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/* */
/* comments configured for C2LATEX and LATEX */
/* ***** */
#define GRAPH_LIB          /* provides the data definitions */
#include "srbgraph.h"

/* ***** */
/* scale the X-axis data to fit in the current window */
/* ***** */
int far window_x(float x)
{
    int temp;

    x -= WIND[INDEX].UX1;
    temp = (WIND[INDEX].AX * x);

    if (temp > MAXX)
    {
        temp = MAXX;
    }

    return((temp < 0) ? 0 : temp);
}

/* ***** */
/* scale the Y-axis data to fit in the current window */
/* ***** */
int far window_y(float y)
{
    int temp;

    y -= WIND[INDEX].UY1;
    temp = (WIND[INDEX].BY - WIND[INDEX].AY * y);

    if (temp > MAXY)
    {
        temp = MAXY;
    }

    return((temp < 0) ? 0 : temp);
}

```


F .21 SYM_CIR.C

```
/* ***** */
/* SYM_CIR.C */
/* */
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/* */
/* comments configured for C2LATEX and LATEX */
/* ***** */
#define GRAPH_LIB          /* provides the data definitions */
#include "srbgraph.h"

/* ***** */
void far draw_circle(float xr, float yr)
{
    circle(window_x(xr), window_y(yr), WIND[INDEX].SYMBOLSIZE);
}
```

F .22 SYM_CROS.C

```
/* ***** */
/* SYM_CROS.C */
/* */
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/* */
/* comments configured for C2LATEX and LATEX */
/* ***** */
#define GRAPH_LIB          /* provides the data definitions */
#include "srbgraph.h"

/* ***** */
void far draw_cross(float xr, float yr)
{
    int x, y, sym_size = WIND[INDEX].SYMBOLSIZE;

    x = window_x(xr);
    y = window_y(yr);

    line(x - sym_size, y, x + sym_size, y);
    line(x, y - sym_size, x, y + sym_size);
}
```

F .23 SYM_DIAM.C

```
/* ***** */
/* SYM_DIAM.C */
/* */
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/* */
/* comments configured for C2LATEX and LATEX */
/* ***** */
#define GRAPH_LIB          /* provides the data definitions */
#include "srbgraph.h"
```

```

/* ***** */
void far draw_diamond(float xr, float yr)
{
    int x, y, sym_size = WIND[INDEX].SYMBOLSIZE;

    x = window_x(xr);
    y = window_y(yr);

    line(x - sym_size, y, x, y - sym_size);
    line(x, y - sym_size, x + sym_size, y);
    line(x + sym_size, y, x, y + sym_size);
    line(x, y + sym_size, x - sym_size, y);
}

```

F .24 SYM_SQR.C

```

/* ***** */
/* SYM_SQR.C */
/* */
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/* */
/* comments configured for C2LATEX and LATEX */
/* ***** */
/* symbol drawing routines */
#define GRAPH_LIB /* provides the data definitions */
#include "srbgraph.h"

/* ***** */
void far draw_square(float xr, float yr)
{
    int x, y, sym_size = WIND[INDEX].SYMBOLSIZE;

    x = window_x(xr);
    y = window_y(yr);
    rectangle(x - sym_size, y + sym_size, x + sym_size, y - sym_size);
}

```

F .25 SYM_STAR.C

```

/* ***** */
/* SYM_STAR.C */
/* */
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/* */
/* comments configured for C2LATEX and LATEX */
/* ***** */
#define GRAPH_LIB /* provides the data definitions */
#include "srbgraph.h"

/* ***** */
void far draw_star(float xr, float yr)
{
    int x, y, scale = WIND[INDEX].SYMBOLSIZE;
}

```

```

x = window_x(xr);
y = window_y(yr);

line(x - scale, y, x + scale, y);
line(x, y - scale, x, y + scale);

scale *= 0.707;

line(x - scale, y + scale, x + scale, y - scale);
line(x - scale, y - scale, x + scale, y + scale);
}

```

F.26 SYM_TRI.C

```

/* ***** */
/* SYM_TRI.C */
/**/
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/**/
/* comments configured for C2LATEX and LATEX */
/* ***** */
#define GRAPH_LIB          /* provides the data definitions */
#include "srbgraph.h"

/* ***** */
void far draw_triangle(float xr, float yr)
{
    int x, y, sym_size = WIND[INDEX].SYMBOLSIZE;

    x = window_x(xr);
    y = window_y(yr);

    line(x - sym_size, y + sym_size, x, y - sym_size);
    line(x, y - sym_size, x + sym_size, y + sym_size);
    line(x + sym_size, y + sym_size, x - sym_size, y + sym_size);
}

```

F.27 SYM_X.C

```

/* ***** */
/* SYM_X.C */
/**/
/* This file contains part of a windowing graphics package written by */
/* Steven R. Brown and edited by Robert D. Hardy */
/* Sandia National Laboratories Dept. 6117. */
/**/
/* comments configured for C2LATEX and LATEX */
/* ***** */
#define GRAPH_LIB          /* provides the data definitions */
#include "srbgraph.h"

/* ***** */
void far draw_x(float xr, float yr)
{
    int x, y, sym_size = WIND[INDEX].SYMBOLSIZE;

```

```
x = window_x(xr);
y = window_y(yr);

line(x - sym_size, y + sym_size, x + sym_size, y - sym_size);
line(x - sym_size, y - sym_size, x + sym_size, y + sym_size);
}
```

G BUILDTC.C

```

/* ***** */
/* BUILDTC.C */
/* Program to build spline tables for thermocouple data in DATAVG. */
/* */
/* Written by: */
/* Robert D. Hardy */
/* Sandia National Laboratories */
/* Dept. 6117 */
/* April 17, 1992 */
/* */
/* Comments configured for C2LATEX and LATEX*/
/* */
/* ***** */
/* The first line of a data set contains the thermocouple type */
/* letter followed by the number of data points to follow (N). */
/* Input data is temperature, millivolts pairs separated by commas */
/* with one point per line. */
/* */
/* This program computes coefficients and creates a file containing */
/* the voltage, temperature and coefficient numbers with voltage */
/* scaled for board gain of 100 as done on the Keithley AIM7. The */
/* output consists of N sets of numbers preceded by a header line. */
/* The header gives the thermocouple type letter in upper case */
/* followed by the number of points in the data (N). Each data */
/* point occupies one line in the file. The line contains three */
/* columns of ASCII characters with comma separators. The columns */
/* are temperature, voltage and the coefficient numbers in that */
/* order. */
/* */
/* The data for each type of thermocouple follows the same format */
/* with no particular order. This allows flexibility in */
/* configuration for a particular requirement. If few thermocouple */
/* types are used the tables may be small and therefore consume less */
/* memory. */
/* ***** */

#include <stdio.h>

#include <stdlib.h>

#include <ctype.h>

#include "spline.h"

void get_temp(void);

void put_temp(void);

/* arrays used for spline fitting to thermocouple data */
/* allow for 1000 points */
double xa[1000];          /* Voltage */

double ya[1000];          /* Temperature */

double y2a[1000];         /* Spline coefficient */

```

```

int n;

char type;

FILE *cfg;

FILE *output;

void main(void)
{
    if((cfg = fopen("temp.d","r")) == NULL)
    {
        puts("Error, input file not found");
        exit(1);
    }

    if((output = fopen("thermo.cfg","w")) == NULL)
    {
        puts("Error, unable to create output file");
        exit(1);
    }

    while(!feof(cfg))
    {
        get_temp();                /* read input data into arrays */

        /* compute coefficients */
        spline(xa, ya, n, 1e30, 1e30, y2a);

        put_temp();                /* write results to a file */
    }
    fclose(cfg);
}

/* ***** */
/* */
/* Read a file containing temperature, voltage pairs. One pair */
/* per line. The first line contains the type letter and point */
/* count in that order. Voltage readings are in millivolts. This */
/* function multiplies them by 100 for the board gain then divides */
/* by 1000 to get volts. The multiply divide operation is lumped */
/* by dividing each voltage reading by 10.0 which is the net */
/* effect. */
/* ***** */
void get_temp(void)
{
    int i;

    fscanf(cfg,"%c,%d\n", &type, &n);

    for(i=0;i<n;i++)
    {
        fscanf(cfg,"%lg,%lg\n", &ya[i], &xa[i]);

        xa[i] /= 10.0;
    }
}

```

```

/* ***** */
/* Create a file containing the processed input data and the */
/* coefficient data. The first line is the type character */
/* followed by the point count. The rest of file is voltage, */
/* temperature, coefficient all on one line with commas for */
/* separators. The file is ASCII real. */
/* ***** */
void put_temp(void)
{
    int i;

    /* write type character and point count */
    fprintf(output,"%c, %d\n", toupper(type), n);

    /* write data table for this type */
    for(i=0;i<n;i++)
    {
        fprintf(output,"%lg, %lg, %lg\n", xa[i], ya[i], y2a[i]);
    }
}

/* ***** */
/* SPLINE.C */
/* Taken from Numerical Methods in C */
/* */
/* Given arrays x[1..n] and y[1..n] containing a tabulated function, */
/* i.e.  $Y_i = f(X_i)$ , with  $X_1 \leq X_2 \leq \dots \leq X_n$ , and given values ypi and */
/* ypn for the first derivative of the interpolating function at */
/* points 1 and n respectively, this routine returns an array */
/* y2[1..n] that contains the second derivatives of the */
/* interpolating function at the tabulated points  $X_j$ . If ypi and/or */
/* ypn are equal to 1e30 or larger, the routine is signaled to set */
/* the corresponding boundary condition for a natural spline, with */
/* zero second derivative on that boundary. */
/* */
/* Modified to use zero based array indices by decrementing the */
/* pointers. */
/* ***** */

#include "spline.h"

#ifdef __TURBOC__
    void spline(double *x,double *y,int n,double yp1,double ypn,double *y2)
#else
    void spline(x,y,n,yp1,ypn,y2)
        double *x;

        double *y;

        int n;

        double yp1;

        double ypn;

```

```

        double *y2;
    #endif
    {
        STATIC int i,k;
        STATIC double p,qn,sig,un,*u;

        --x;    /* decrement pointers for index correction */

        --y;

        --y2;

        u = alloc((n-1)*sizeof(double));

        /* Set the lower boundary to be "natural" or to have a specified first derivative. */
        if(yp1 > 0.99e30)
            y2[1] = u[1] = 0.0;
        else
        {
            y2[1] = -0.5;
            u[1] = (3.0 / (x[2] - x[1])) * ((y[2] - y[1]) / (x[2] - x[1]) - yp1);
        }

        /* This is the decomposition loop of the tridiagonal algorithm. */
        /* y2[] and u[] are used for temporary storage of the decomposed factors. */
        for(i=2;i<=n-1;i++)
        {
            sig = (x[i] - x[i-1]) / (x[i+1] - x[i-1]);
            p = (sig * y2[i-1]) + 2.0;
            y2[i] = (sig - 1.0) / p;
            u[i] = ((y[i+1] - y[i]) / (x[i+1] - x[i]))
                - ((y[i] - y[i-1]) / (x[i] - x[i-1]));
            u[i] = ((6.0 * u[i]) / (x[i+1] - x[i-1])) - ((sig * u[i-1]) / p);
        }

        /* Set the upper boundary to be "natural" or to have a specified */
        /* first derivative. */
        if(ypn > 0.99e30)
            qn = un = 0.0;
        else
        {
            qn = 0.5;
            un = (3.0 / (x[n] - x[n-1])) * (ypn - (y[n] - y[n-1]) / (x[n] - x[n-1]));
        }

        y2[n] = (un - qn * u[n-1]) / ((qn * y2[n-1]) + 1.0);

        /* This is the back-substitution loop of the tridiagonal algorithm */
        for(k=n-1;k>=1;k--)
            y2[k] = (y2[k] * y2[k+1]) + u[k];

        free(u);
    }

```


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