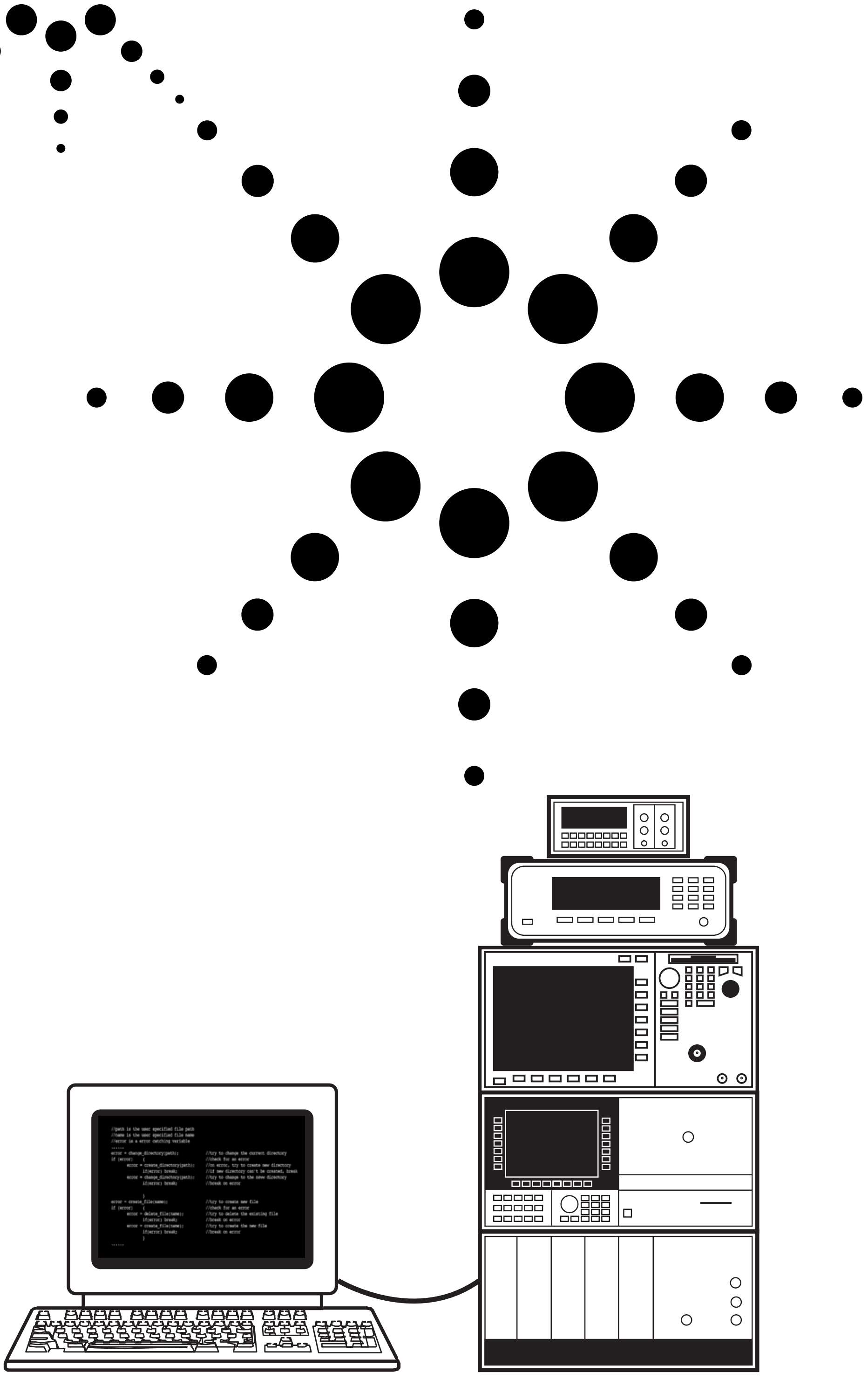
Data Logging using Remote Programming

Application Note 1370-1



```
//path is the user specified file path
//name is the user specified file name
//error is a error catching variable
......
error = change_directory(path);          //try to change the current directory
if (error)     {                         //check for an error
       error = create_directory(path);   //on error, try to create new directory
              if(error) break;           //if new directory can't be created, break
       error = change_directory(path);   //try to change to the neww directory
              if(error) break;           //break on error

              }
error = create_file(name);               //try to create new file
if (error)     {                         //check for an error
       error = delete_file(name);        //try to delete the existing file
              if(error) break;           //break on error
       error = create_file(name);        //try to create the new file
              if(error) break;           //break on error
              }
......
```

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Introduction

One of the most obvious and useful applications of remote programming of test instruments is to run the same test periodically and simultaneously, saving the data from each measurement to the computer's hard drive. This allows an instrument to continuously monitor a system without user interaction for hours or even days at a time. For instance, a test could be set up using an Agilent 86100A Infiniium DCA (digital communications analyzer) to measure the extinction ratio every thirty seconds for an hour. Similarly, an Agilent 8614XB optical spectrum analyzer (OSA) could measure signal-to-noise ratio in a DWDM system once an hour for two days. Unfortunately, this is deceivingly complex and requires a surprising amount of programming overhead. In addition to the usual programmatic requirements for controlling and communicating with the instrument or instruments, the program must include functions which incorporate user inputs and controls, file set-up and I/O, the delays between measurements, and elementary error handling.

Remote programming is the process of using a PC to issue commands to an instrument and read measurement results back to the PC. This is most commonly done using a General Purpose Interface Bus (GPIB) in accordance with the IEEE 488.2-1992 standard. Agilent manufactures GPIB cards for PC's as well as UNIX® workstations and also Ethernet-to-GPIB gateways. Additionally, virtually all of Agilent's lightwave instruments are equipped for remote programming via GPIB and come with documentation on the commands and functions available. Almost any command which can be input through the instruments front panel has a remote command equivalent.

The simplest format in which to output data is a delimited ASCII text file. A delimited ASCII text file is a simple text file where a specific character, usually a *tab* or *comma*, separates each datum. Additionally, this type of file offers excellent generality. An ASCII file can easily be transferred to a number of database (such as Oracle® 8 or Microsoft® Access) and spreadsheet programs (such as Microsoft Excel or Lotus® 1-2-3). Most other file formats require a file header which is unique to that file format. In addition to limiting the output file's compatibility to one program, writing the header requires additional program complexity. Many commonly used programming languages (including Microsoft Visual C++ and Visual Basic, National Instruments LabView, and Agilent VEE) include ActiveX controls which allow direct data transfer into database and spreadsheet programs but this approach adds complexity and is again done at the cost of generality. A text file format offers the maximum of simplicity and generality and as such is perfect for example purposes.

Programming Specifics

1. Prompt the user for test duration, frequency, output path, etc.
2. Set up the instrument and the output file(s).
3. Perform measurement and gather data from the instrument.
4. Perform running calculations (for example average, minimum, maximum).
5. Send data to the output file (can be performed after the loop).
6. Wait until it is time for the next measurement.
7. Repeat steps 3–6 until the time limit, an error, or asked to stop.

Figure 1. Program Outline

With the added complexity of elements including user input, file I/O, and error handling, program flow becomes an issue of utmost importance. The first step is to prompt the user for the necessary information such as the delay between measurements, the total test duration, and the name and location of the output file. After the necessary information is received from the user, the program must set up the specified output file and establish communication with the instrument or instruments. After this step, the program enters a loop which is repeated until the specified time limit is reached, an error occurs, or the user aborts the program. With each iteration of this loop, the data is acquired from the instrument, any necessary calculations are performed, the data is formatted and sent to the output file, and the program simply pauses until it is time to repeat the loop. An outline of the program can be seen in Figure 1.

The user input is one of the simpler facets of a data-logging program. Graphical languages like LabView and VEE are designed with user interface as a top priority. In such languages, setting up a user input is as simple as dragging and dropping a few boxes. Even in C++ or Visual Basic, getting a simple input from the user is not difficult. In C++, the simplest way is to prompt the user by printing a text string to the program window, and then looking at the user's response. In Visual C++ or Visual Basic, one can even use "forms" which use familiar MS Windows® controls. One important thing not to overlook, however, is to check for errors in this process. When using pre-made input functions like those in graphical languages, invalid inputs are usually disallowed, so these types of errors are less of a problem. On the other hand, in a language such as C++ the program may prompt for a length of time and there is nothing to stop the user from typing in his or her name, if for no other reason than to see if the programmer was being careful. Malicious inputs aside, it is quite possible for the user to make a typo or other mistake and the program must be designed to deal with input errors.

The next step is to set up the instrument and the output file. The language and the operating system used determine the complexity of this step. Error catching is vital in this step as the user can input file and path names which may not exist which can cause errors. In MS Windows, for example, an error may be caused if the user specifies a directory that is not present, a file that already exists, or both. It is vital that the program knows what to do in any case. It is simple enough to create a new directory or overwrite an old file, but the program must know how and whether or not to perform these tasks. An example of what this may look like is shown in Figure 2, page 4. Notice that the program first assumes that the directory exists and that the file does not exist. If there is a problem, it assumes that the source of error was the directory needing to be created or the file needing to be cleared and then the program performs the appropriate task. This very simple error correction will handle the vast majority of errors stemming from the file set-up step. It is also necessary in most languages to set up an output stream to the output file. An output stream is simply memory buffer that holds the data while the file is being written. This usually only requires a few lines of code, but error checking is necessary here as well.

The other part of the set-up step in the program is to set up the instrument. This step includes verifying the communications link and establishing communication with the instrument. This is usually also the appropriate time to change the instrument or instruments to the desired settings. In some cases, it may be necessary to change the settings periodically. For instance, one measurement may be taken in

```
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//name is the user specified file name
//error is a error catching variable
......
error = change_directory(path);           //try to change the current directory
if (error)     {                          //check for an error
       error = create_directory(path);    //on error, try to create new directory
              if(error) break;            //if new directory can't be created, break
       error = change_directory(path);    //try to change to the neww directory
              if(error) break;            //break on error

              }
error = create_file(name);                //try to create new file
if (error)     {                          //check for an error
       error = delete_file(name);         //try to delete the existing file
              if(error) break;            //break on error
       error = create_file(name);         //try to create the new file
              if(error) break;            //break on error
              }
......
```

Figure 2. Psuedocode example of error catching for a new file

decibels and another in watts. In such a case the settings would have to be changed between measurements or as part of each measurement process. However, one-time settings changes, such as selecting the output format, should also be done in this step. Again, it is important that the program be equipped to handle common errors from this process and provide the user with information on any errors. For instance, if a communications link cannot be set up, the program should identify that as the problem. It is far easier to find and correct a problem in the system if the program informs the user from where the error originates.

After all of the necessary parameters have been gathered and the set up is complete, the real work of the program can begin. The first step of the measurement loop, of course, is to actually take the measurements. After the GPIB link has been set up, it is usually just a matter of sending string commands over the link and then reading the response. As usual though, error checking is vital. Any number of problems can develop while making a measurement and the program must be equipped to deal with them. When an error is encountered by the instrument, it stores an error code and description in a special buffer which can be retrieved by the program (usually using the ":SYST:ERR?" command in SCPI compliant instruments) which can in turn be used in the program's error handling routines. SCPI (Standard Command for Programmable Instruments) is a series of industry-wide instrumentation standards regarding how instrument commands are structured and contains several common commands. Another advantage of this strategy is that the programmer can define their own errors even if there are no real programmatic or link errors. For example, the programmer can set limits on the measurements such that if the measurement moves out of a certain range, for instance the signal-to-noise ratio gets too low, the program will stop and an error message will appear. With well-designed and implemented error handling, this is quite easy.

After the measurements have been made, the program can make any necessary calculations such as averaging, minimum and maximum values, or any number of other statistical calculations. Two related reasons exist for doing these calculations here rather than after all of the data has been gathered. First is memory management. This is not really a problem when the data set is ten points, but if the data set has ten million points, it can cause a slowdown in performance. Second, it can be difficult to run calculations on large data sets. Finding the average of ten million points, for example, could take as long as a few seconds, depending on the computer, the algorithm, and the language in which the program is written. One the other hand, if the data is calculated as the data comes in, there is no delay at the end of the program and far less memory is required. Less memory is needed because the new data can be written over the old data in memory as it comes in since the old data has already been stored in the output file. Additionally, even if the calculation is quite complex, the performance slowdown can be worked into the delay function of the program and, as such, there will not be any noticeable delay. A ten-second calculation makes little difference to the user if it is completed during a ten minute delay between measurements.

The next step is to write the data to the text file. In most cases, this involves only converting the data to a string format and then sending that string to the output file. Most instruments give the option of returning the measurement values in an ASCII format which means the conversion may be unnecessary, the strings need only be concatenated. Additionally, the program must add some recognizable delimiter character between the measurements. This is required so that the database or spreadsheet can tell when one number ends and the next begins. As mentioned earlier, the most commonly used delimiting characters are *tab* and *comma*. Two complications can force a change in this step. First, if for instance, the measurements produce a table of data it may require that a new text file is created with each iteration. An example of such a case is if the user might want to record channel number, wavelength, power, and signal-to-noise ratio for each channel in a DWDM system. A new text file would have to be set up each time this set of measurements was taken. The second variation can come if it is necessary to output all of the data at one time. An example may be that some calculation must be delayed until all of the data has been gathered, or the output to the text file is too complicated or time consuming so it should be done only once. In such a case, the data would be collected from all of the measurements, whether it is into an array or a string, and then written to the output file only after the program had completed. As each measurement was taken, each individual datum would be appended to the data which had already been collected. Remember, however, that this is done at the cost of memory usage and system performance.

The final step in the loop is for the program to wait until it is time for the next measurement. This step is really the heart of the program. On the surface, it seems very simple, but it is deceivingly complex. First of all, the *wait* function must allow the user to abort the program. The reason for this is if there is some problem and the user needed to stop the program, it would be quite frustrating to wait for the entire test duration to fix a simple problem. Second, the program should use a minimum of system resources during this step. It makes no sense to tie up the computer while this program is simply waiting until the next measurement. At first look, the programmer may want to use a *sleep* or *wait* command for the duration of the measurement period. This function, in effect, stalls the program for a certain duration of time and uses very little system resources. Unfortunately, this simple solution has a couple of problems. First is that most *sleep* and *wait* functions do not allow the user to abort the function. That is, if the user presses the *abort* button or key, the program will not even look at the *abort* button until the *sleep* function is complete. For example, if the measurements are being taken once every hour, the *abort* command may take an hour to be read, which makes the *abort* button all but useless. It seems that an easy solution to this problem would be to remove the *sleep* function and start a sub-loop that repeatedly checked if the user entered the *abort* command until the specified time limit was reached. The problem with this approach is that it uses far too much processor power as the program is occupying system resources to perform these tasks, but is not doing any useful work. The optimum solution lies somewhere in the middle between using a single *sleep* function for the duration of the delay and using a loop without any *sleep* function. That is, for the program to sleep for a short period of time, check for the *abort* command, and then loop until the *abort* command is seen or the time limit is reached. The sleep time could be a half-second, fast enough that the user may not even notice the delay if they abort the program, but far long enough that the processor can perform many other tasks in the mean time. The overall wait function would then look like something like the code in Figure 3.

The second complexity is that the measurements and even sometime the writing of the file can take seconds or in some cases even minutes and may not require exactly the same amount of time with each iteration. As such, it is necessary to subtract the completion time from the other steps in the loop from the overall wait time so that the entire process takes a consistent and predictable amount of time. Measuring this completion time is usually easy enough to accomplish by simply storing the system time when the measurement and file writing processes start and end and then finding the difference of the two. The required cycle wait time is then the total wait time minus the measurement time.

At this point, it is time to repeat the entire measurement loop. The loop should be repeated until an error is encountered, an abort command is given, or the time limit is reached. If properly coded, the abort command can be treated as an error. By doing this the loop need only check for an error or the time limit instead of checking for an abort command separately.

The error-handling function should be performed after the program exits the loop. All this function needs to do is output a description of the error encountered. The error can simply be coded as a number; for instance error number one is a failure to open the file, error number two is a GPIB problem, and so on. The error catching function would consist basically of a lookup table that would take the error code as a number and output the description.

One can completely automate the process of both the measurement and data transfer and storage processes using simple remote programming. This means that no operator is needed to press the buttons on the instrument nor write down the results and type them into a database, it is all done in the program. The program required for such a process is not overly complex nor is it by any means extremely simple.

```
//wait time - the amount of time to wait (in milliseconds)
//stop - boolean whether the user has aborted the program

j = 0; //initialize a counter
while (j  < wait_time && !stop){    //loop until time limit or
abort
          sleep(500);               //sleep .5 seconds
          stop = user_abort();      //check for user abort
          j = j+500;                //increment the counter
}
```

Figure 3. Pseudo code example of wait function

Appendix A: Visual C++ Example

The following is an example of a datalogging program written in Microsoft Visual C++. It is important to note that no actual measurements are taken in this program in the interests of generality. Instead, dummy functions which return random numbers are used as place holders.

```
/*————————————————————————————————————————
Program:      Datalogger v1.0
Start Date:   August 25, 2000
Last Modified: September 7,2000
Language:     Visual C++, v6.0
Description: Datalogger is an example program which demonstrates how a test can repeated at a
  specified interval over a period of time. The data is then logged into a tab delimited stan-
  dard ASCII text file which can be imported into a spreadsheet or database program.
        To make the program more general, no actual measurements are taken. Instead, dummy
  methods are used to return dummy values to illustrate the concepts, rather than actually make
  a measurement.

The basic program structure is as follows:
       1.     Set up the instrument and the output file(s)
       2.     Perform measurement and gather data from the instrument
       3.     Send the data to the output file and perform running calculations
              (e.g. averaging, min, max)
       4.     wait specified time (e.g. 1 minute)
       5.     repeat 2-4 until the time limit or asked to stop

Note:  This example is provided as an illustration “as is”, and Agilent Technologies makes no
       warranty of any kind with regard to this example.
————————————————————————————————————————*/
//LIBRARY CALLS
#include <windows.h>   //windows functions
#include <stdio.h>     //standard i/o library
#include <conio.h>     //more i/o functions
#include <time.h>       //time functions
#include <direct.h>     //directory functions
#include <io.h>                 //file io functions
#include <sys/stat.h>  //constants
#include <stdlib.h>    //standard functions
#include <fstream.h>   //File i/o library


//PROTOTYPES
int wait(int tme, time_t start);
int creatFile(char path[], char fileName[]);
int Measures(double *ans, time_t *tmStmp);
int Msrmnt1(double *ans);
int Msrmnt2(double *ans);
int Msrmnt3(double *ans);
int DataToString(double data[3], time_t TmStmp, char *dat);
int Get_Time(char name[], long *num);
int Get_String(char name[], char *str);
int Error_Catch(int Error_Code);
int Inst_Setup(int Addr);
int init_stats(double measures[3], double *max, double *min, double *mean);
int stats(double measures[3], double *max, double *min, double *mean, int j);
int print_stats(double max[3], double min[3], double mean[3]);

/*————————————————————————————————————————
```

```
Function: Main   (INCOMPLETE)
Description:  The main function is the backbone of the program. It makes the calls the various
other methods and functions and controls program flow.

Inputs: None
Output: int  - represents an error, if any.
———————————————————————————————————————*/
int main( void ){
//Declarations
  time_t start, stamp;              //the start time of the program and timestamp holder
  double meas[3], *mes;             //an array for holding measurement data and a pointer
  double max[3], min[3], mean[3];   //arrays for holding min/max/mean
  double *mx, *mn, *ave;            //pointers to those arrays
  int i = 0, err=0;                 //int counter and error code
  long duration, period;            //long ints for test duraion and period
  char data[256], *dat;             //a string for the data and a pointer to it
  char file[256], *fil;             //a string for the file name, and a pointer
  char path[256], *pat;             //a string for the path, and a pointer

  mes = meas;                       //assign the pointers to the arrays
  dat = data;
  pat = path;
  fil = file;
  mx = max;
  mn = min;
  ave = mean;

  err = Get_String("File Name (e.g. c:\\loggeddata\\)", pat);    //prompt for the path
  if(err !=0) return Error_Catch(err);     //check for errors

  err = Get_String("Path (remember the file extension '.txt')", fil);  //prompt for the file name
  if(err !=0) return Error_Catch(err);     //check for errors

  printf("data will be written to %s%s.\n",path, file);

//print the path and file name

  err = creatFile(path, file);             //create output file
  if(err !=0) return Error_Catch(err);     //check for errors

  ofstream out(file);                      //declare output stream "out"
  if (!out) return  Error_Catch(-1);       //exit if an error occurs while opening the file

  err = Get_Time("duration", &duration);   //prompt the user for test time
  if(err !=0) return Error_Catch(err);     //check for errors

  err = Get_Time("period", &period);       //prompt user for the measurement period
  if(err !=0) return Error_Catch(err);     //check for errors

  printf("duration:\t%d\tperiod:\t%d (secs)\n", duration, period);
                                           //print the test duration and period in seconds

  err = Inst_Setup(717);
  if(err !=0) return Error_Catch(err);     //check for errors

  time (&start);                           //find the start time of the program; the current time

  err = Measures(mes, &stamp);              //take the first Measurements
  if(err == 0){                                 //check for errors
    DataToString(mes, stamp, dat);          //convert the data to a string
    printf("%s", data);                     //print the data
    out <<data;                             //write data to the file
    init_stats(meas, mx, mn, ave);          //initiate the running stats
  }//if(err == 0)

  while(i*period<duration && (err == 0) && ((err = wait(period, start))==0)){
        //loop until the test duration is completed or the program is aborted
   err = Measures(mes, &stamp);             //take the Measurements
   if(err == 0){                            //check for errors
      DataToString(mes, stamp, dat);        //convert the data to a string
      printf("%s", data);                   //print the data
  out <<data;                               //write data to the file
  time (&start);                            //update the time
  i++;                                      //increment the counter
  stats(meas, mx, mn, ave, i);              //calculate the running stats
}//if(err == 0)
  }//for()

  print_stats(max, min, mean);
  return Error_Catch(err);
} //main()
/*————————————————————————————————————————
Function:     Wait
Description:  The WAIT function simply stalls the computer between measurements. It polls the
  keyboard to see if any key was pressed, if so, the program stops and an error message is
  displayed. This is to allow the user to abort the program at any point. The method uses the
  sleep() method (in windows.h) to save on processor usage during the stalls.

Input: int time - specifies the number of seconds for which the method is to run.
Output: int - represents an error, if any.
       0 - no error
       1 - program aborted
————————————————————————————————————————*/
int wait(int tme, time_t start){

   //Declarations
   int ch1;                 //ch1 is used to hold keyboard data, i tracks the # of runs
   time_t finish;           //finish is the finish time of the method
   double elapse;           //elapse is the run time of the method

   do
   {
   Sleep(500);              //wait 500ms (.5 seconds)
   ch1 = _kbhit();          //if a key was pressed, ch1 gets a nonzero value
       elapse = difftime(time (&finish), start);   //calculate the elapsed time
   } while((ch1 == 0) && (elapse<tme));
                            //repeat until time expires or a key press
   if (elapse < tme){       //determine if a key was pressed
   getch();                 //clear the pressed keyfrom the keyboard buffer
   return 1;                //return error code 1 (program aborted by user)
   }  //if
   else{                    //no key was pressed
       return 0;            //return no error code
   }  //else
}                           //wait()
/*————————————————————————————————————————
```

```
Function: creatFile()
Description:  the function creatFile creates a text file with a given name
in a given directory. If and Error is encountered, an error message
appears on the debug screen

Inputs:
path[]     string (char[]) naming the destination directory
filename[]  string (char[]) naming the destination file
Outputs:
int -1 error in creating the file or changing directory
       0  no error
————————————————————————————————————*/

int creatFile(char path[], char fileName[]){

int dr, dr1, fil;                    //variable declarations used for error checking
                                     //dr stores the output of chdir()
                                     //dr1 is used to recheck if the first chdir() fails
                                     //fil stores the output of creat()

dr = chdir(path);                    //change directory to the designated path

if (dr!=0){                          //check for errors in changing directory
       dr1 = chdir("c:\\");          //change the directory to 'c:\'
       if (dr1 != 0) return -1;      //if that fails, return error
       dr1 = mkdir(path);            //try to create a new directory
       dr1 = dr1 + chdir(path);      //try to move to that directory
       if(dr1!=0)                    //recheck for error
         return -1;                  //return error code and quit function
} // if(dr != 0)

fil = _creat(fileName, S_IWRITE);   //creates a file named as designated

if (fil == -1)                       //check for errors in creating the file
       return -1;                    //return error code and quit function

return 0;

} //creatFile

/*—————————————————————————————————————
Function: Measures()
Description:  the Measures function calls the individual measurement functions and adds a time
  stamp and then returns the data as a "Data" structure.

inputs: *ans[] - a pointer to the destination of the measurement data
       *tmStp - a pointer to the destination of the time stamp
outputs:  int - error code
                      0 - no error
                      2 - measurement error
——————————————————————————————————————*/
int Measures(double *ans, time_t *tmStmp){
//Declarations
    int err=0;               //error code

err = Msrmnt1(ans);          //take the first measurement
if (err == 0)                //check for error
```

```
    err = Msrmnt2(ans+1);    //take the second measurement
if (err == 0)                //check for error
    err = Msrmnt3(ans+2);    //take the third measurement

time(tmStmp);                //current time is the timestamp

return err;
}//Measures()
/*________________________________________
Function: Msrmnt1()
Desription: Msrmnt1 simply a dummy function which returns a random double. It should be
  replaced by a function which actually takes a measurement.

inputs: double *ans - pointer to the answer destination
output: int - error catcher
                      0 - no error
                      2 - measurement error
_______________________________________*/
int Msrmnt1(double *ans){
double num = rand();         //create a random number
*ans = num;                  //place it in the pointed location
return 0;                    //return "no error"
}
/*________________________________________
Function: Msrmnt2()
Desription: Msrmnt2 simply a dummy function which returns a random double. It should be
  replaced by a function which actually takes a measurement.

inputs: double *ans - pointer to the answer destination
output: int - error catcher
                      0 - no error
                      2 - measurement error
_______________________________________*/
int Msrmnt2(double *ans){
double num = rand();         //create a random number
*ans = num;                  //place it in the pointed location
return 0;                    //return "no error"
}
/*________________________________________
Function: Msrmnt3()
Desription: Msrmnt3 simply a dummy function which returns a random double. It should be
  replaced by a function which actually takes a measurement.

inputs: double *ans - pointer to the answer destination
output: int - error catcher
                      0 - no error
                      2 - measurement error
_______________________________________*/
int Msrmnt3(double *ans){
double num = rand();  //create a random number
*ans = num;           //place it in the pointed location
return 0;             //return "no error"
}
/*________________________________________
```

```
Function: DataToString
Description: DataToString converts the data (an array of three doubles)
  and the time stamp into a string, which can then be exported to the text file.

inputs:  double[3] data - the measurement data
        time_t TmStmp - the time stamp
         char *dat - pointer to the soutput string
Output:  int - error code (always 0)
———————————————————————————————————————*/
int DataToString(double data[3], time_t TmStmp, char *dat){

struct tm *StructTime;              // a time structure which will hold the time stamp

StructTime = localtime(&TmStmp);    //convert the time_t to a tm structure

sprintf(dat, "%f\t%f\t%f\t%s",data[0],data[1],data[2], asctime(StructTime));
              //build the string and store it in the pointer location

return 0;
}//dataToString()

/*—————————————————————————————————————
Function: Get_Time()
Description:  this function prompts the user for a time value in hh:mm:ss
format and then returns the number of seconds.

inputs: Char[] name   - the name of the time to be propted
       long *num - a pointer to the total number of seconds

output: int - error code
                      0 - no error
                      3 - user input error
———————————————————————————————————————*/

int Get_Time(char name[], long *num){
  int hours, minutes, seconds;             //declarations

  if(printf("What is the test %s (hh:mm:ss)?", name) <0)  //prompt the user
  return 3;                                //and check for error

  if(scanf("%d:%d:%d", &hours, &minutes, &seconds) != 3)  //scan the input
  return 3;                                //and check for error

  *num = hours*3600 + minutes*60 + seconds;//calculate the total number of secs

  return 0;
//return "no error"
}
/*—————————————————————————————————————
Function: Get_String()
Description:  this function prompts the user for a string value.

inputs: Char[] name   - the name of the string to be propted
       long *str - a pointer to the total number of seconds

output: int - error code
                      0 - no error
                      3 - input error
———————————————————————————————————————*/
```

```
int Get_String(char name[], char *str){

  if(printf("What is the %s?", name) <0)  //prompt and check for error
  return 3;

  if(scanf("%s", str) != 1)                //scan the user input and check for error
  return 3;

  return 0;                                //return "no error"
}
/*________________________________________
Function: Error_Catch()
Description:  Error catch is a very simple error handling function which prints the error to
 the output screen then echos the input

Possible Error Codes:
0 - no Error
-1 - Error in opening or creating the output file
1 - Program Aborted by the User
2 - Error in Measurement
3 - Error in User input
4 - Instrument setup error

input:  int errorCode - the code of the error present
Output: int - error code (identical to the input)
_______________________________________*/

int Error_Catch(int Error_Code){
switch(Error_Code){
       case 0:  //no error case
              printf("Program Completed Sucessfuly!\n");
              break;
       case -1:  //file error case
              printf("ERROR: Cannot create/open output file\n");
              break;
       case 1:  //program aborted
              printf("ERROR: Program aborted by the User\n");
              break;
       case 2:  //measurement error
              printf("ERROR: Error in taking measurement\n");
              break;
       case 3:  //User input error
              printf("ERROR: User input Error\n");
              break;
       case 4:  //instrument setup error
              printf("ERROR: Cannnot setup instrument interface\n");
}//switch(Error_Code)
return Error_Code;
}//Error_Catch()
/*________________________________________
```

```
Function: Inst_Setup()
Description:  this is a very simple dummy program which simply returns 0. In an actual test
  system, this would be replaced by code to set up the instrument, now it is simply a place
  holder.

inputs: int Addr - address of the instument
output: error code 0 - no error
           4 - instrument set-up error
_______________________________________*/
int Inst_Setup(int Addr){
//insert instrument setup code here
return 0;
}//Inst_Setup()
/*______________________________________
Function: init_stats()
Description:  intit stats simply copies the first measurement's data into the
  min, max and mean arrays.

inputs:  double[3] measures - the meausrement data
       double *max - pointer to the maximum arrays
       double *min - pointer to the minimum array
       double *mean - pointer to average array
output: int - error code (always 0)
_______________________________________*/
int init_stats(double measures[3], double *max, double *min, double *mean){
for(int i=0; i<3; i++){    //cycle through measurements

       *max = measures[i];          //place the data in the max....
       *min = measures[i];          //min.....
       *mean = measures[i];         //and mean arrays.

       max++;                       //increment the pointers before moving to the
       min++;                       //next measurement
       mean++;
}//for
    return 0;
}//init_sata()
/*______________________________________
Function: stats()
Description:  stats updates the running stats (min, max, and mean). It is very similar to
  init_stats.

inputs:  double[3] measures - the meausrement data
       double *max - pointer to the maximum arrays
       double *min - pointer to the minimum array
       double *mean - pointer to average array
       int j - the number of measurements, which have bee taken
output: int - error code (always 0)
_______________________________________*/
```

```
int stats(double measures[3], double *max, double *min, double *mean, int j){
for(int i=0; i<3; i++){    //cycle through measurements

       if (measures[i] > *max)
         *max = measures[i];        //place the data in the max....

       if (measures[i] < *min)      //min.....
         *min = measures[i];

       *mean = (measures[i] +  (*mean) * j)/(j+1);               //and mean arrays.

       max++;                       //increment the pointers before moving to the
       min++;                       //next measurement
       mean++;
}//for
    return 0;
}//init_sata()
/*——————————————————————————————————————
Function: print_stats()
Description: print_stats simply prints the running stats at the end of the
program.

inputs:
double[3] max - the maximums of the measurements
double[3] min - the minimums of the measurements
double[3] mean - the arithmetic means of the measurements
outputs:
int - error code (always 0)
——————————————————————————————————————*/
int print_stats(double max[3], double min[3], double mean[3]){
printf("max value:\n%f\t%f\t%f\n", max[0], max[1], max[2]);
printf("min value:\n%f\t%f\t%f\n", min[0], min[1], min[2]);
printf("ave value:\n%f\t%f\t%f\n", mean[0], mean[1], mean[2]);
return 0;
}//print_stats()
```

Appendix B: LabView Example

The following figures show a National Instruments LabView version 5.1 example of a datalogging program. The first figure is a program hierarchy illustration followed by pictures of each individual program function.

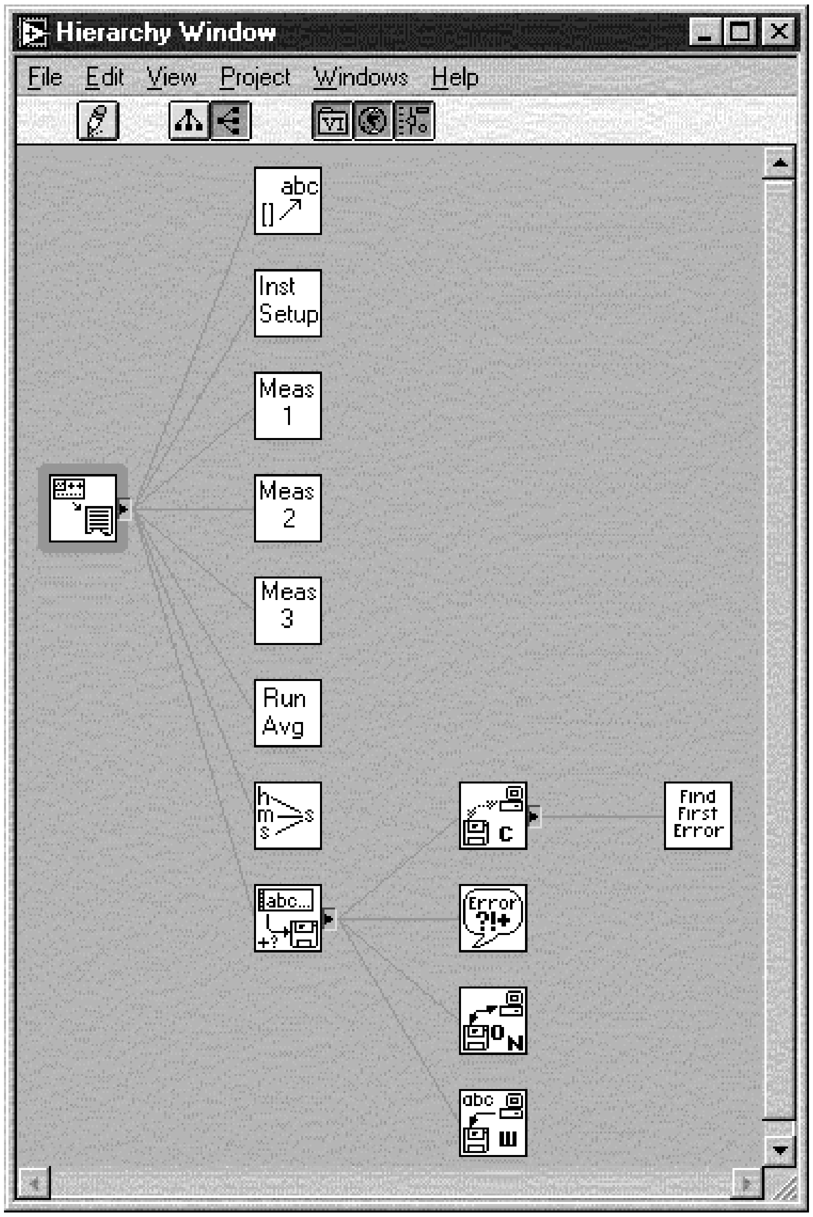
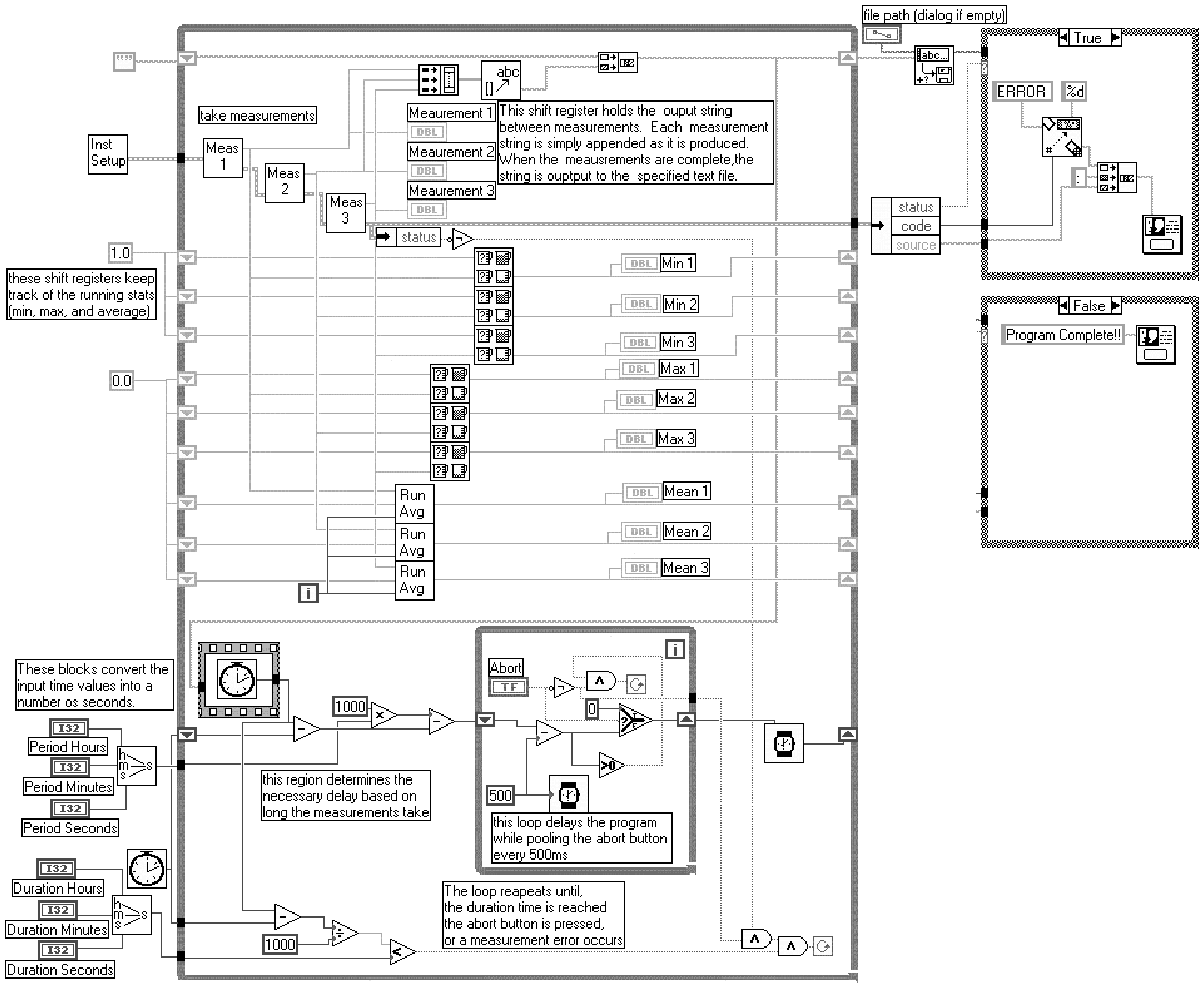


Figure B-1. Hierarchy of the LabView datalogging example.



This shift register holds the ouput string between measurements. Each measurement string is simply appended as it is produced. When the meausrements are complete,the string is ouptput to the specified text file.

these shift registers keep track of the running stats (min, max, and average)

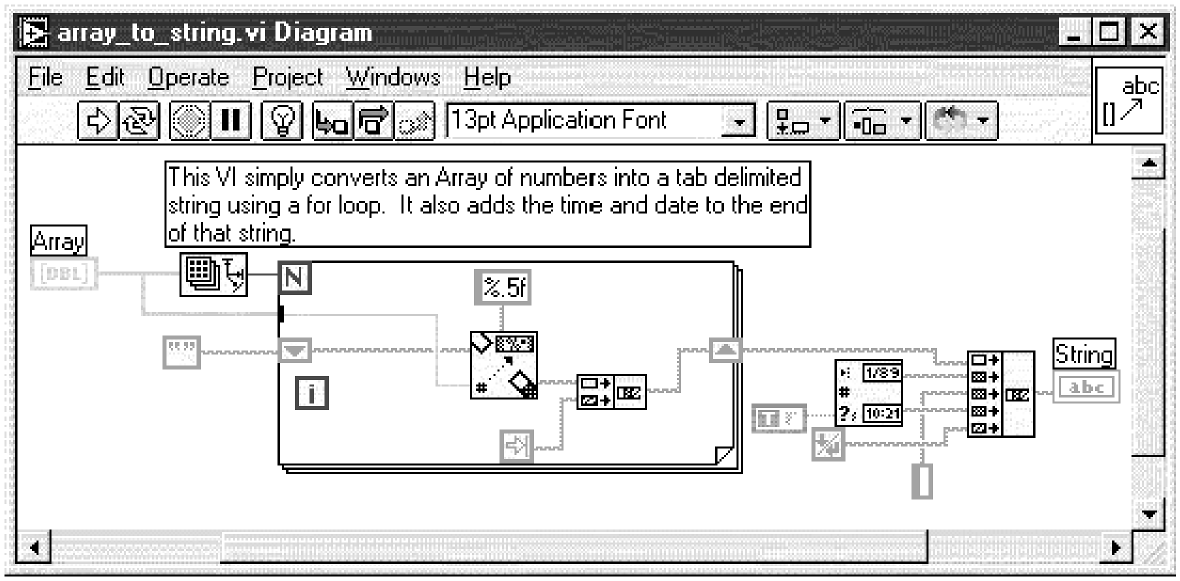
These blocks convert the input time values into a number os seconds.

this region determines the necessary delay based on long the measurements take

this loop delays the program while pooling the abort button every 500ms

The loop reapeats until, the duration time is reached the abort button is pressed, or a measurement error occurs

Figure B-2. The main program module of the LabView datalogging program.


array_to_string.vi Diagram
File Edit Operate Project Windows Help
13pt Application Font
abc
Array
DBL
N
%.5f
i
String
abc

This VI simply converts an Array of numbers into a tab delimited string using a for loop. It also adds the time and date to the end of that string.

Figure B-3. The *array_to_string* function converts the raw data into a string with a time stamp which can then be written to the output file.

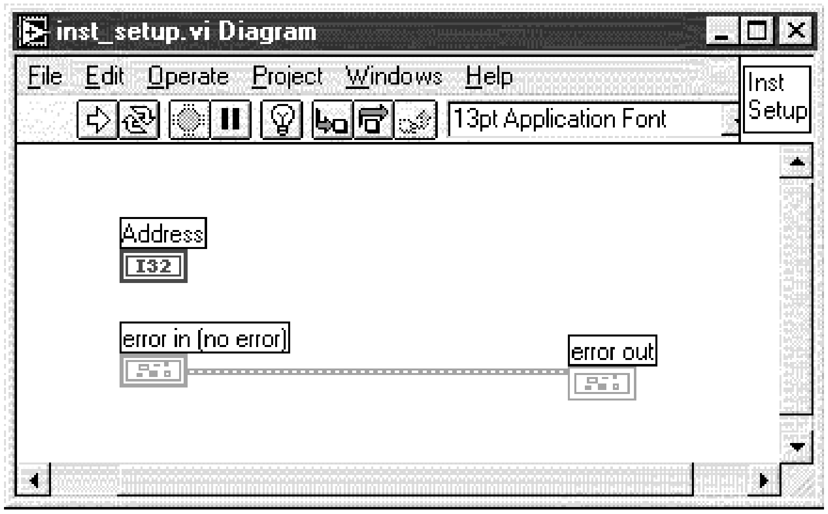


Figure B-4. The *inst_setup* function is a dummy function. It's only functionality is to pass on any errors passed to it. This is where the instrument setup functionality should be inserted.

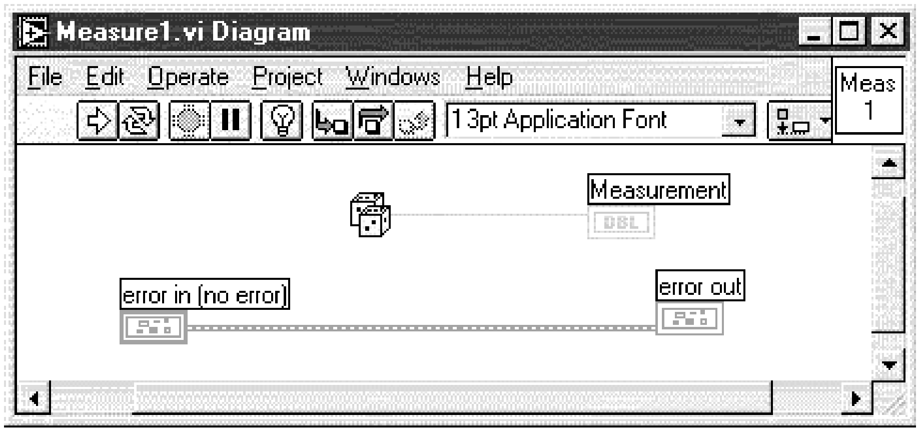
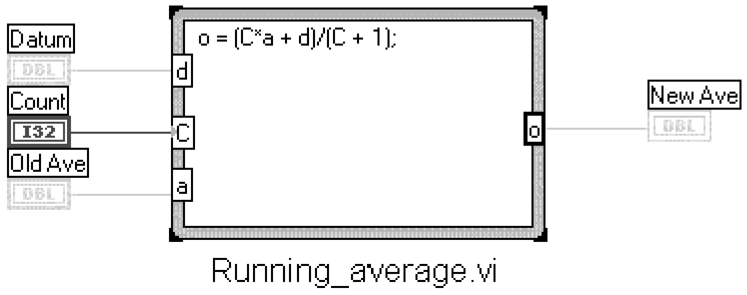


Figure B-5. The measurement functions are also dummy functions. They simply return a random number. Shown is the first of three identical functions. These functions would be replaced with actual measurement functions.



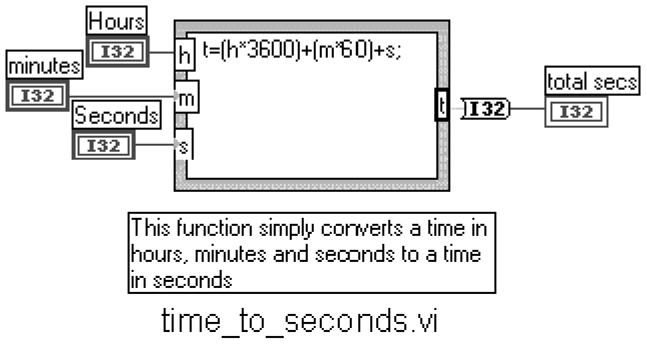

Hours
I32
minutes
I32
Seconds
I32
h
m
s
t=(h*3600)+(m*60)+s;
t
I32
total secs
I32
This function simply converts a time in hours, minutes and seconds to a time in seconds
time_to_seconds.vi

Figure B-6. The *running_average* and *time_to_seconds* functions are simple mathematical functions. They are put in separate files in order to save space in the main funciton.

All of the other functions are standard LabView v5.1 modules. See the LabView help files for documentation on these modules.

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