

CADI Software Manual

edited December 1996; Feb, Mar 1997; Feb, Dec 2000; May 2002

By: John Mac Dougall, University of Western Ontario
email: jmacdoug@uwo.ca

1. Operating software overview

There are two main programs for operating the CADI ionosonde: **CADITEST** and **CADIRUN**

CADITEST

As its name implies the program CADITEST is used for checking the CADI system to make sure it is working satisfactorily. When you run this program you are presented with a menu of choices that enables you to try out various modes of operation by moving the selection arrow up and down and pressing return. You should use this program to familiarize yourself with the various CADI modes. When this program runs it first reads data about your CADI configuration from the file LOCATION.INI (see below for description of this file), so it won't run if it cannot find this file (no other files are needed).

CADIRUN

This is the program used for collecting data. When it runs, instructions are read from various files which tell this program when to collect data and what data to collect. The only operator interaction is to press <esc> to terminate running this program and return to the pc operating system. At most sites this program runs automatically when the pc is turned on because, if there is a power outage you want the pc to resume data collection when the power returns. The automatic start for this program is controlled by the AUTOEXEC.BAT file, which is almost always located in drive C:

A typical operating sequence for this program is as follows:-

1/ The pc is turned on or the RESET button is pressed [It is important, if you are collecting data, that the CADI be started by rebooting the computer (pressing RESET) not by running the CADIRUN program. This allows the pc batch files (see below) to control such things as the tape backup on successive days.]

2/ The pc starts and runs the AUTOEXEC.BAT file which contains, as its final line: CADI.BAT This switches control to CADI.BAT which must be in the same directory as AUTOEXEC.BAT. CADI.BAT is described in detail below but briefly, at startup, it switches to the directory that contains CADIRUN and starts this program.

3/ When it starts, CADIRUN reads information about the CADI configuration from the file LOCATION.INI (the same file read by CADITEST). The contents of this file are described below.

4/ Next a file called CADISCHD.ULE is read. This file tells the CADI what modes to run, and what is to be the interval between runs. As an example, I will assume that two modes called "MODE_A" and "MODE_B" are to be run and that MODE_A is to be run once each hour (3600

seconds between runs), and MODE_B is to be run once each 15 minutes (900 seconds between runs). The basic information in this file would then be: MODE_A 3600 MODE_B 900 (see below for more details about the CADISCHD.ULE file).

5/ The mode definition files for all the modes specified in CADISCHD.ULE are read. For the present example, definition files MODE_A.DEF and MODE_B.DEF would be read. These mode definition files are described below. They tell the CADI what frequencies to use, what signal processing, etc for each mode.

6/ The CADI will then run the modes specified until either: (A) the CADISCHD.ULE file has told the CADI to run different modes at some later time, or (B) it is time to exit the CADIRUN program and do a tape backup (or a time check if there is a GPS receiver). When it exits the CADIRUN software, control returns to the CADI.BAT file. See description of this file below for a typical tape backup sequence which is done before restarting the CADIRUN data collection again.

2: Running the CADI

Firstly, CADI runs under DOS. There is of course a 'historical' reason for this, but also the DOS system is a stable unchanging system. In general, running the CADI under Windows does not work.

Apart from testing, one usually wants the CADI to start automatically when the computer is turned on. This makes sure that after a power failure the operation will automatically restart. To have this happen, the AUTOEXEC.BAT file needs to be edited so as to automatically start the CADI software. There are various possibilities for this, as follows:-

- a) A few lines can just be added to the end of the AUTOEXEC.BAT file. Example: adding the lines (*comments are in italics*):-

D: *switches to drive D: The CADI software can be on any drive that you choose.*

cd cad_i_exe *goes to directory D:/cad_i_exe On whichever drive you choose for the CADI you will need to have a directory CADI_EXE for the CADI software, and a directory CADIDATA for the data.*

cadirun *starts cadirun program*

- b) If there is a more elaborate sequence of commands associated with running the CADI then it will probably be better to put them in a file called CADI.BAT. This file should be in the root directory of drive C: Then at the end of AUTOEXEC.BAT just put CADI to have it go to the CADI.BAT file.

An example of a CADI.BAT file that is used to have an automatic daily backup to a Colorado tape is given on the next page. Here is a simpler example of a CADI.BAT file that does a reset from a GPS clock once a day:-

D:

cd cad_i_exe

presskey *see description of this program below*

if errorlevel 1 goto endloop *presskey returns a 1 if a key has been pressed*

:loop *program repeats from here*

cadirun *setting the 'backup time' in the LOCATION.INI file (see below) to, say, 0 would have the CADI exit the CADIRUN program each day at 0 hours*

if errorlevel 1 goto timeset *when the CADI runs, if the exit is the 'backup time' the program returns a 1, otherwise if the exit is due to the operator pressing <esc> then the program returns a 0*

goto endloop

:timeset

settime *call the program for resetting the clock*

goto loop

:endloop *exit CADI.BAT*

c) Here is a much more complicated CADI.BAT that copies data to a backup tape:

Listing of CADI.BAT for automatic Colorado tape data backup, with explanation

d:	Switch to D: drive (see note below about drives)
cd \cadi_exe	Switch to \cadi_exe directory
presskey	Start Presskey.exe
if errorlevel 1 goto endloop	Check the return value from presskey if any key is pressed return value will be 1 and endloop will be called.
:loop	Start main operating software
 cadirun	Check return value from cadirun
 if errorlevel 1 goto dobackup	cadirun will return a 1 if the backup time has been reached. If ESC is pressed 0 will be returned and endloop called
 goto endloop	
:dobackup	
 cd \	Change to root dir
 ECHO y chkdsk /f	Check drive for corrupted files.
 if not exist file0000.chk goto end	If corrupted files are found
 copy file*.* \cadidata	copy them to \cadidata
 del file*.*	and delete them from the root directory
:end	
 echo Start tape store	
 cd \cadi_exe	
 tape search/ v=1>\cadi_exe\tapeinfo.dat	Check tape status to determine space left on tape.
 filesize	Check size of all datafiles to be backed up. If there is
 if errorlevel 1 goto loop	no space on tape return to main operating software
 tape backup \cadidata*.*	else start backup.
/A/B="badlist.log"/I/J/-K/M >	
\cadi_exe\cadiback.log	After backup is complete remove all datafiles from
 echo Start cleanup	hard drive directory \CADIDATA\.
 cleanup	
 backuplg	Run backuplg to prepare the message about tape
	usage that is displayed on the screen.
 goto loop	Finally return to main operating software.
:endloop	
 cls	Clear screen and exit to DOS prompt

Programs called by CADI.BAT in the above listing:-

PRESSKEY.EXE

This program clears the screen and prompts the user to press any key within one second to exit to a DOS prompt. If no key is pressed the program then exits with a return value of 0, which calls the CADI operating software CADIRUN.EXE. If a key is pressed, presskey returns an exit number of 1.

FILESIZE.EXE

This program reads the file TAPEINFO.DAT and then checks the size of the files in \CADIDATA\. If the files will fit on the tape then a backup is done (exit number is 0), if not (exit number is 1) then more data will be accumulated until the operator puts in a new tape. Note: when you put in a new tape (one with no 'volumes' written on it) the TAPE SEARCH program (part of the manufacturer's tape operating system) will not correctly return the information about the amount of space available. You must manually write 1 volume to the tape. If you have some datafiles in your \CADIDATA\ directory then the batch process NEWTAPE.BAT will do this if you run it.

The reason for all this is as follows: If the data tape fills during a backup the computer will stop and wait until someone puts in a new tape. This means no data will be collected until the operator changes tapes. The above procedure using FILESIZE doesn't attempt to write to the tape unless there is enough space. If there isn't enough space on the tape then data continues to accumulate in the \CADIDATA\ directory, and a message displays telling the operator that the tape needs changing.

CLEANUP.EXE

This program looks to see if the backup flag is set in each file in \CADIDATA\, if so the file has been stored on tape and is therefore erased.

BACKUPLG.EXE

This program takes the file \CADI_EXE\CADIBACK.LOG that was created when the backup was done and uses the information from it to make a string that is stored in \CADI_EXE\CADIBACK.STR. This file contains the information about tape usage which is displayed at the top of the screen when the CADI is collecting data.

CADIRUN.EXE

CADIRUN.EXE is the main data collection program for CADI. It uses three (or more) auxiliary files when operating. These files are **LOCATION.INI**, **CADISCHD.ULE** and any mode definition files specified in CADISCHD.ULE. The mode definition files are explained below.

They have a file extension **.DEF** All of these files are ASCII text files and can be edited using DOS EDIT or any other text editor that the user is familiar with.

CADIRUN.EXE can be configured to run in various modes. For instance it can create multiple ionograms stored in files created once per hour, or create a single file for each ionogram. The only option the user has while this program is running is ESC to quit. If ESC is pressed the operating software will exit to DOS as soon as it completes its current operation.

Two details about CADIRUN:-

a) Time:- The CADIRUN software assumes that the CMOS real-time clock in your computer is more accurate than is the software real-time clock used by the pc. In normal operation the software real-time clock is set from the cmos clock when you first turn on the computer, and thereafter the time is taken from the software real-time clock, which is often quite inaccurate. The CADIRUN program resets the software real-time clock from the cmos clock at the beginning of each hour.

b) Fault detection: The CADIRUN software attempts to determine if there is a fault in one, or more, receivers by comparing the received signal levels. This is done by summing, for each receiver, the power received at all heights and all frequencies used by a mode. Obviously much of what will be summed will not be ionospherically reflected CADI signals, but will be background noise, etc. The summed power levels are then compared and if any receiver has a power level less than 1/9 of another receiver a message is displayed warning the operator. This is an attempt to detect major failures, the operators should still be looking at the received echoes to make sure that they have, on average, closely similar amplitudes from all the receivers.

Files called by CADIRUN

LOCATION.INI

The following is a copy of the LOCATION.INI file and (*italicized*) a explanation of each line. This file can be edited by the user, using a text editor, such as DOS EDIT. The names or numbers in front of the italicized explanation should be changed to suit your CADI configuration. Don't edit the lines starting with ! since the first 17 characters are required to match those encoded in the software.

!station name is (3 characters)

UWO - *The station name can be any three characters which identify the location of the CADI site.*

!time error of CMOS clock in seconds per day (floating pt number)

0.0 - *This was used to compensate for clock error. It isn't used by recent versions of the operating software. Just leave it as 0.0*

!pulse rate (pulses per second)

40 - *The standard pulse rate for the CADI to transmit is 40 pulses per second. The pulse rate from this file will be put into data headers and used by the data analysis software. If you do not know the pulse rate, run CADITEST and select choice #2, after 1000 pulses have been transmitted the calculated pulse rate is*

shown on the screen. It should be 40 or, for 1020 km height range, 20.

!hour to do backup (integer)[if hour > 23 then no backup]

0 - *The backup of data files from the hard drive to tape is done once every 24 hours. The hour in which the backup is to be done is selected here. If no backup is to be done this number should be set to 24 or greater(eg set backup hour to 25).*

!number of receivers (integer 0 <-> 4)

4

!type of DDS chip (char O = old parallel port DDS, S = 1st SIL DDS, N = new SIL DDS,T,U)

N

!height range max (must be either 510 or 1020)

510

!GPS clock? (NO, TC1=Trimble on Com 1, TC2, noreset)

TC2

Notes: Most of these table entries are obvious. Your CADI has certain built in properties such as the pulse rate, number of receivers, type of DDS chip, and height range. This table just tells CADIRUN and CADITEST what these built in properties are. You might be uncertain about the type of DDS chip. The only 'O' chips are in some Original receivers that I have. Therefore your chips will be either 'S' or 'N'. These refer to two different versions of the DDS chips. The earlier chips are 'S' and then the manufacturer made some changes and the later chips are 'N'. However we recently purchased a chip and it turned out to be an 'S'. What is best to do is to look at the local oscillator signal going to each of the receivers via a small coax (see hardware manual). Try both S and N (run CADITEST) and look at the local oscillator waveform. Use whichever of S or N gives you a clean sinewave for the local oscillator.

Newer DDS types are T and U: T is S type with MODES, and U is N type with MODES. When you run CADITEST you will see several extra options if MODES are available. (MODES are available on the newer CADI systems produced by SIL, and on some older modified systems.)

The extra options are:-

- a) heightrange (maximum height) can be 510 or 1020. (If you select 1020 then the pulserate is changed to 20 pps instead of 40 pps.)
- b) delayed code can be turned ON or OFF
- c) can select LISTEN for which there is no transmitter output
- d) can use EXTERNAL GPS TRIGGER (1 per sec) instead of the internal timer trigger (usually 40 pps).
- e) can use 7 bit Barker code instead of 13 bit. This allows lower minimum height for useful data.

The line about GPS clock should be set to NO even if you have a Trimble GPS clock attached unless you want to take all your time from the GPS clock instead of from the PC clock. You would then use the GPS clock just to do a daily reset of the pc clock by putting a suitable line in the CADI.BAT file (see later section "GPS time routines").

The usual operation of cadi is to assume that the CMOS clock in the pc is more accurate than the times determined by the pc using the timer interrupt (the standard way of determining pc time is to read the CMOS clock on startup and afterwards determine time using the timer interrupt) and therefore once an hour the pc clock is reset from the cmos clock. However in some cases the CMOS accuracy may be poor or certain hardware clocks periodically reset the pc clock. Therefore there is the alternative of not doing the hourly reset by setting the GPS clock line to "noreset". If you choose "noreset" then the time is displayed in magenta colour, otherwise it is displayed in yellow colour.

CADISCHD.ULE

The CADISCHD.ULE file tells the CADI operating software what modes to run and at what times to run them. Note that this is an ASCII text file and can be edited with a text editor to suit the user's application. The lines in the file have the following format:-

<TIME> <MODE DEFINITION FILE> <INTERVAL TIME> <COMMAND>

TIME - the time at which the CADI operating software starts to run the current mode.

MODE DEFINITION FILE - see file description below

INTERVAL TIME- the time in seconds between repeat runs of this mode

COMMAND - REPEAT or QUIET

The purpose of this file is best explained by giving some examples:

Example 1: One sequence that repeats for the whole day. The file has just 1 line:

```
00:00:00 IGRAM95 900 FHT2FREQ 30 REPEAT
```

This example tells the operating software to start the sequence at 00:00:00 UT. The sequence begins by running a mode defined in a mode definition file called IGRAM95.DEF, and this is repeated every 900 seconds (15 min). A second mode defined by the mode definition file FHT2FREQ.DEF next runs and it repeats every 30 seconds. This sequence repeats continuously throughout the day. The IGRAM95 mode take precedence over the FHT3FREQ mode. (Modes earlier in the list take precedence over later listed modes.) This means that if the mode FHT2FREQ cannot finish before the next run of the IGRAM95 mode starts then the FHT2FREQ mode won't run (except once so the software can find out how long each mode takes to run).

Note that when the IGRAM95 mode runs, then the run of the FHT2FREQ mode will be delayed until it finishes, and if IGRAM95 took more than 30 sec to run then the of the FHT2FREQ run for that 30 sec interval will not be done. If you want to have FHT2FREQ mode run for every 30 sec interval you would need to list FHT2FREQ first to give it higher priority. (ie 00:00:00 FHT2FREQ 30 IGRAM95 900 REPEAT) For this to run the way you expect it to you need to make sure that both modes can run in a 30 sec interval (otherwise the IGRAM95 mode won't run

[except once at the beginning of each hour when the computer determines how long it takes each mode to run]).

Example 2: A more complex daily sequence. The file has several lines.

```
00:01:20 igram95 900 fht2freq 30 REPEAT
04:00:00 QUIET
06:00:00 igram95 900 igram70f 300 fht2freq 30 REPEAT
```

This example tells the CADI system to run, for hours starting at 00:01:20 to 04:00:00, the same modes as the first example. Then do nothing from 04:00:00 to 06:00:00. At 06:00 the second sequence starts and runs to 00:01:20. This sequence is similar to the first sequence, but has an additional mode igram70f that runs every 300 seconds (5 mins). Note that you can specify that the sequences start at a particular minute and second value.

IGRAM95.DEF (This is an example of a mode definition file. Each mode specified in the CADISCHD.ULE file must have a mode definition file)

This file contains the information used to set the operating mode and frequency generation of the CADI system. Explanations are *italicized*.

!low resolution' ionogram mode definition Mode name. You can write anything that you want on this line since the line is just a comment and isn't actually used by the software.

!file extension (3char)

md2 - *This is the file extension which each of the data files written by this mode will use. The file extension is the only way of distinguishing files containing data from a particular mode since the 8 characters of the filename are used for date and time. The filenames consist of a date and time string plus the extension specified here. For example a data filename for this mode might be: 2A120417.MD2 This filename is 2=2002, A = January (B = February, etc), 12 = the day, 4 = the hour, 17 = the minute.*

Note about year: 1992 would also be 2 for the year. It is assumed that the file would be saved in a directory where the year is expanded (ie all files for station Delaware for this day are saved in a directory 020112DE).

Note about minute: If all data for this hour are saved in the same file (see next section) then 'minute' is the minute when the file was first opened.

Note about extension: Although you can use any 3 letter extension the standard data analysis software does make some assumptions based on the file extensions.

Therefore the standard extensions are:

MD1 (or md1) height range 510 km, drift file using 1 or more 'fixed' frequencies

MD2 (or md2) height range 510 km, ionogram file

MD3 (or md3) same as MD1 but height range 1020 km

MD4 (or md4) same as md2 but height range 1020 km

!file structure (I=individual run in file, H=all runs for hour in file)

- H - *There are two alternatives for storing data files. The first alternative is (I) individual. For this I alternative each time a mode runs it makes a new datafile. The second alternative is (H) hourly. In the H alternative all runs of a mode in the period of an hour will be stored in the same datafile. Usually the H alternative is preferred because you don't end up with large quantities of small files.*

!data processing 1/Single/Barker 2/no_of_samples_to_average 3/FforNone 4/samplesize 5/data display (see Software Manual)

B 1 F 8 amplitude

- *This line sets the operating mode for the system. The letter selects the transmitter mode. S sets it in single pulse mode, which transmits a single pulse 40 usec at each frequency in the frequency table. B sets Barker mode. In this mode the transmitted signal is Barker code modulated. A new choice (micro code versions 5 +) is C for Complementary. This is an 8 bit code that uses a pair of different codes. When using Complementary you **must** do averaging of at least 2 pulses. The advantage of Complementary is that there are no coding sidelobes, and the minimum height range can be set as low as 60 km.*
- *The second number represents the number of samples to average before displaying the result, and storing the data. This number can be either 1 (no averaging) or 2ⁿ (maximum 256).*
- *The third letter enables or disables Fourier transform processing being performed on the data. F processes the data using a Fast Fourier Transform and N uses no processing.*
- *The fourth number sets the number of samples used in the Fourier transform. Must be 2ⁿ (maximum 512).*
- *There are quite a few options for the display name. When doing the normal data collection the display name is: amplitude, a second type of display for swept frequency is: ionogram. You should be cautious about using an ionogram display if you want the mode to run quickly. The ionogram display uses higher level graphics that run much slower than the assembly language graphics used for the amplitude (I_Q) display. The ionogram display allows the use of a mouse (if present) to read values from the ionogram. If the CADI has MODES available, and a GPS clock input, then you can use it as part of an oblique sounding system (see later section of this manual). The usual display for an oblique sounder is an ionogram (so choose ObliqueIonog). However, you can choose an amplitude display (choose ObliqueAmpl). There is also the option of not transmitting but just listening when doing an oblique ionogram. The choices then are:- ObliqueIonogL and ObliqueAmplL.*

!base threshold (floating_point)

- 4.0 - *Thresholding is used to only save signal levels that are of significance (ie not noise or interference).*

Thresholding uses 2 parameters: Base threshold and Noise threshold that are given in

this file. The following describes what these two parameters do.

Let us assume that there is an echo but there is also some noise or interference. Usually you only want to save echoes that have higher power than the noise or interference (otherwise what you save might be just the noise or interference). What is done is that the noise or interference level is estimated by integrating the received power for all heights and finding the average.

*This 'average noise power' is then multiplied by the '**Noise Threshold**' to give a threshold value above which echoes would need to be in order to be saved.*

*However for some locations and frequencies the threshold determined above might be very close to 0. To further save storage, echo signals that are insignificantly small, even though they are higher than the calculated threshold, can be rejected by using the '**Base Threshold**' to get rid of these very weak echoes.*

***Base threshold**, used as mentioned above to get rid of insignificantly weak echoes of only 1 or 2 units amplitude. It is specified as power so an amplitude of 2 units would mean a Base Threshold of $2^2 = 4.0$. A value of 4.0 is a fairly typical Base Threshold.*

!noise threshold (floating_point)

1.3 - *The way this is used is described above. It is usually the more critical threshold parameter. Although not mentioned in the discussion above, the received echoes usually have FFT signal processing applied to them. The average noise power that is calculated is before any FFT processing. Since FFT processing generally improves the signal-to-noise ratio, this noise threshold can often be set < 1.0 and still not save too much 'noise' because the noise is suppressed by the signal processing. Getting the best setting of this parameter is somewhat a matter of trial-and-error. You can try various settings of these two thresholds using the CADITEST program.*

Note: If you want to save all the data (and noise, etc) you should set both thresholds to 0.

!minimum significant Doppler components before saving data for a height

1 - *For some applications you can reduce the amount of data saved by specifying that several Doppler components must be above threshold*

!minimum height in kilometers

90 - *This value sets the minimum height for data that will be displayed and recorded in the data files. If you set this < 90 km, and modes are available, then the length of the Barker sequence is changed from 13 bits to 7 bits.*

!maximum height in kilometers

510 - *This value sets the maximum height for data that will be displayed and recorded in the data files. This is normally 510 km. If you set this > 510 but < 1020 , and modes are available, then the overall height sampling is changed to 1020 and the pulserate is reduced from 40 to 20 pps.*

!gain control (char) ['N'= none, '0'..'7'= set gain, 'A'= automatic

N - *You can set the input attenuator value in 5 dB steps between 0 and $7*5 = 35$ dB. If you specify a value (N) it is set to $2*5 = 10$ dB. Automatic is not implemented at this time.*

A new alternative (2002) in Versions 5 of CADIRUN and CADITEST is to use automatic gain control (automatic attenuator setting). To use this option the gain control line would be of the form: A0830 (Automatic followed by 2 digit numbers specifying the minimum and maximum noise levels). When the program encounters a mode that specifies automatic gain control the following happens: At the beginning of each hour, for any mode that specifies automatic gain control, the program measures the average noise power (as mentioned above in the threshold section), without transmitting if this option is available, the (noise power)^{1/2} is compared to the two noise values specified and, if possible, the attenuators are adjusted to put the (noise power)^{1/2} between the min and max noise levels specified. The attenuator value is then saved and used for the remainder of the hour for this mode. This is done for each frequency. While the attenuator setting is being done you will see a screen display with a yellow text line that tells about the attenuator settings. Typical min and max noise values are about 10 and 40. You can try various values using the CADITEST program.

!number of frequencies (number followed by the frequency table)

95 - *This is the number of frequencies in the table.*

- *The following list contains all the individual frequencies.*

0 1.5e+06
 1 1.56e+06
 2 1.58326e+06
 3 1.62661e+06
 4 1.67114e+06
 5 1.71689e+06
 6 1.7639e+06
 7 1.81219e+06
 8 1.86181e+06
 9 1.91278e+06
 10 1.96515e+06
 11 2.018e+06
 ... would continue to 95 frequencies ...

If you are making up a new mode with many frequencies (e.g. an ionogram mode) it would be tedious to enter all the frequencies manually. To simplify the process a program MAKEFREQ.EXE can be used to make the frequency table (see MAKEFREQ.EXE below).

Other software

CADITEST.EXE

When setting up a CADI system CADITEST.EXE can be used to test the system. This program allows the user to test all the different modes of operation. To use the program power up the fully connected CADI transmitter and then run CADITEST.EXE and use the up and down arrow keys to select an option from the menu.

The file LOCATION.INI is called by this program.

NEWTAPE.BAT

For use to write files from the directory /CADIDATA/ to a 'new tape'. A tape needs to have at least one 'volume' written to it before the tape software can determine how much space is available on the tape. You can use NEWTAPE to write a volume to the tape.

Make sure there is some data in the /CADIDATA/ directory so that this procedure will be able to write a volume to the new tape. After they are written to the tape the datafiles will be erased from the /CADIDATA/ directory.

MAKEFREQ.EXE

This program is used to create the file of transmit frequencies used for the ionogram. The program first requests that the user enter a filename. The frequencies produced will be stored in an ASCII (text) file of that name. Next the start and end frequency is entered. The user must then choose the number of individual frequencies to be generated. The user may next choose linear or logarithmic frequency spacing. The file of transmit frequencies will then be created.

Having made up the frequency table as a text file, most (even elementary) word processors will allow you to paste this into another file to construct a mode definition (normally you would construct a new mode by editing an existing mode file).

3. Producing your own versions of CADIRUN and CADITEST

Some users with special requirements may want to produce their own versions of the CADI system software. Source code is normally available by ANONYMOUS FTP (username is 'anonymous', password is 'guest') from DANLON.PHYSICS.UWO.CA subdirectory CADI.SYSTEM.SOURCE

To produce CADITEST you need to compile and link the following C language modules:-

CADITEST.CPP, CADI_INT.CPP, SET_DDS.CPP, UTILITYS.CPP, GRAPHLIB.CPP

You also need to link the graphics driver software supplied with C language (EGAVGA.OBJ for Borland C). All the 'header' information is in the file CADI.H

To produce CADIRUN you need to compile and link:- CONTROL.CPP, YMOUSE.CPP, CADITIME.CPP, UTILITYS.CPP, SET_DDS.CPP, CADI_INT.CPP (and use EGAVGA.OBJ and CADI.H).

4. CADI Data File Format

Format description below is in a quasi C language form. Italicised words are 'keywords' used in C.

Note: in C language a byte is called an unsigned char.

(A) file starts with fileheader which consists of:

```
struct fileheader
{
    char timestamp[25];
    struct datablock dataBlock;
};
```

timestamp is a 25 character ascii string consisting of:-

stationname (3 char) + time when file was opened (space + 21 char)

datablock is as follows:-

```
struct datablock
{
    char filetype; // filetypes are: 'I'= individual files, 'H' = one file per hour
    int no of frequ;
    unsigned char doppler series length;
    int min height;
    int max height;
    unsigned char pulses per sec;
    unsigned char noof pulses averaged;
    int basethreshold100; // basethreshold100 = 100× min power (bits sq.) before save
    int noisethreshold100; // noisethreshold100 = 100×multiplier for average noisepower
                        (bits sq.) to set threshold based on noise
    unsigned char minimum number of dopplers before saving;
    int seconds between samples;
    char gaincontrol; // gaincontrol: 'N'= none, or a number
    char sigprocess; // sigprocess: 'F'=do FFT (then save all components above threshold),
                    'T'= timeseq (FFT, saves entire spectrum if any component is above threshold)
                    'N'= none (save raw data)
    unsigned char number of receivers;
    unsigned char spares[11];
};
```

note on data storage in C language: *char*, *unsigned char* are 1 Byte; *int* are 2 Bytes

(B) next the list of all the frequencies used is written to the file as floating point numbers (4 Bytes each)

(C) next comes the data structured as follows:-

start of next_record:

time_min (Byte)

time_sec (Byte)

start of next_frequency:

gainflag (Byte: E0 (hex) to EF: EF = none)

noiseflag (Byte, F0 (hex) = basethreshold, F1 = noisethreshold)

averagenoise_{power10} (*unsigned int*: $10 \times$ averagenoise_{power})

start of next height:

hnum (Byte) virtual height is $3 \times$ hnum, for extended height range CADIs: if $hnum > 200$
then $hnum = hnum - 200$ and $tnum = tnum + 128$ (use high bit of tnum as a flag)

tnum (Byte): number of Doppler bins saved

for each of the tnum Doppler bins write:

```
{  
  data ((1+2xnumber of receivers) Bytes: Doppler bin # then 2 Bytes real, imaginary  
  components for each receiver)  
}
```

if: more heights goto start of next height,

if: more frequencies goto start of next frequency, else (end of last frequency) so write

endfrequflag (Byte = FF (hex))

if: more records in the file then goto start next record

else end of file

5. FILES REQUIRED FOR CADI OPERATION

In drive C:

CADI.BAT (last line in AUTOEXEC.BAT should be CADI.BAT)

For some users not requiring a complex CADI.BAT file, the commands to start the software can be added to the AUTOEXEC.BAT file (see Section 2 of manual)

If there is backup tape software this is usually in C:\tape\ and you need to have c:\tape\ in the PATH statement in AUTOEXEC.BAT

In drive D: (doesn't have to be D: [see earlier note])

- there should be a subdirectory CADIDATA for data storage

- in subdirectory CADI_EXE
(programs for system operation)

CADIRUN.EXE

CADITEST.EXE

LOCATION.INI

CADISCHD.ULE

mode definition files for any modes in CADISCHD.ULE

PRESSKEY.EXE

(programs associated with the Colorado Tape backup)

FILESIZE.EXE

CLEANUP.EXE

BACKUPLG.EXE

NEWTAPE.BAT

Note: When the tape system runs it writes files CADIBACK.LOG and CADIBACK.STR
-giving information about the tape usage- into this directory.

(utility programs)

MAKEFREQ.EXE

6. Operator Instructions

These instructions are for the CADI hardware arrangement that I have at my field sites. If you have a different arrangement you will need to edit this page.

1/ Does the CADI appear to be running Ok? Screen not frozen, data being collected (if it is time for a run).

2/ Check information on screen.

a) Is time correct to within 10 sec? [Note: time is set to UT, not local time]. If time needs correcting then do the ordinary pc “time” and “date” routines after exiting the CADI operating program.

b) Does the tape need changing? The message at the top of the screen gives information about amount of room left on the tape. If it needs changing you can just ‘pull’ the old tape and put in a new one. [Note: For the tape software to give the correct message on the screen there has to be at least one “volume” written on the tape. I now send out the tapes with a dummy volume written on them (this volume contains just the word “start”). If the tapes have not had a volume written on them you need to write something on them using the tape software (run TAPE, select BACKUP).]

Note that the tape info on the screen doesn’t change at the time you put in a new tape, it only changes at the time there is a tape backup done (usually at 00hrs).

If the tape has become too full to write another day’s data to it, then the “tape full” message will be displayed, and data will continue to be accumulated on the hard drive. If that happens then when you change the tape you should exit the operating program and run NEWTAPE. This will copy the accumulated data to the new tape. If this tape fills then you need to put in yet another new tape. After transferring data, NEWTAPE should erase the datafiles on the hard drive. You should check the CADIDATA directory to make sure this has been done. You can check what is on the tape by running TAPE and then selecting RESTORE, then select a “volume” and an option is to view the volume directory. You don’t actually have to do the restore.

If the hard drive has run out of space to accumulate more data then what usually happens is that the system continues to open data files, but the size of these is 0 bytes.

c) Is there info on screen that indicates a weak receiver? If so the problem is usually in the antenna/preamp/cabling. Check these (see below: inspect antenna and cables for damage). If this does not reveal the problem then see the section “Receiver check and calibration” in this manual.

d) Are all 4 LED indicators on the preamp power supply box lit? (one for each antenna preamp, 4 at my sites) The preamp power supply has constant current output that passes through these LEDs. Therefore if an LED is not lit it tells you that there is no current going out the line that goes to that preamp. Therefore a LED that is not lit tells you that either the cable to the

preamp is open circuited, or the preamp itself is open circuited. There should be a spare preamp at your site so you can usually figure out what is wrong by taking it out and plugging it into the cable where there may be a preamp or cable problem. You can plug it in with the preamp power ON since the constant current power supply isn't bothered if you make a temporary short while you are doing the connection.

e) Are all receivers producing approximately equal output? You may not be able to see if they are without exiting the operating software. (Press <esc>, any routine that is running will finish running before the program exits.) Then select and run CADITEST. Select "(2) fixed freq, Barker code, I_Q". You will get a screen display of the I (inphase) and Q (quadrature) signals (these are showing you the "real" and "imaginary" components of the received signals). The display is colour coded for the 4 receivers. You need to look closely to see the 4 different coloured traces (see colour "key"). If there is an ionospheric echo it will show up as a small positive or negative "bump" in the 100 - 300 (usually) kilometer height range. It will usually show on both the I and the Q displays. If you see an echo look closely to make sure that it has approximately the same average amplitude from all 4 receivers. If you don't see an echo then you may need to select a different frequency. Try changing the frequency to 3 MHz using option (0) on the CADITEST menu. You can also try running option (11) that displays an ionogram. From this display you can decide what would be a good frequency to look at the echo strengths. Note that sometimes you won't be able to get an echo on any frequency (because the ionospheric electron density is too low, or there is too much absorption).

If one, or more, receivers is weak you should first check to see if the LED on the outside preamp is ON. Preamps get damaged by lightning, or by water leaking through the seal. Note also that the LED on the inside preamp power supply box could be ON, and the LED on the outside preamp OFF if the cable has a short. If the cable seems to be Ok and the outside preamp LED is ON, and there is no apparent antenna damage you need to:-

- i) Try the spare preamp to see if that makes any difference.
- ii) Try the "Receiver check and calibration" procedure given in this manual. Our experience is, however, that the problem is almost always in the antenna/preamp/cabling rather than in the CADI receivers.

f) If you have exited the operating software then restart the CADI operating software by pressing RESET (If you restart it any other way then the system will not run the normal sequence of operations that is controlled by the CADI.BAT file.)

Finally fill in the logsheets or logbook.

7. Receiver check and calibration

To check and calibrate the receivers a calibrated signal generator is required.

1/ Set the generator to a frequency of 4.0 MHz (the default frequency for CADITEST). Leave the generator output OFF or at a very low setting.

2/ Connect the generator to whichever receiver you are testing.

3/ Leave the transmitter power amplifier turned OFF. Turn on the CADI pc and run CADITEST. Go to “toggle IQ means” and select this <cr>. The only change when you do this is that the line “IQ means:” at the top of the screen changes from OFF to ON. Go to “(1) fixed frequency, single pulse, I_Q” and select this. You will get a graphical display and the outputs from the receivers will show as coloured lines on the I (inphase) and Q (quadrature) plots. At the bottom of the screen the I and Q means for each receiver are shown. These should all be 128. If these are close to 128 (127 or 129) then you do not need to adjust the “zero offset” controls. If you need to adjust the zero offsets see below. You probably want to do the next check before doing the offset adjustments.

4/ Now set the generator output to a level of -54dBm (446 uV). On the receiver for which the generator is input you should see large sinewaves on the I and Q displays. The sinewave frequency is proportional to the frequency difference between the 4.0 MHz generator frequency and the CADI 4.0 MHz frequency. You can vary the frequency of the sinewaves on the display by slightly varying the generator frequency. The amplitude of the displayed sinewaves should be full-screen. Estimate the amplitudes of the I and Q waves for this receiver. If they aren't closely the same then you should plan on doing a calibration.

5/ Switch the generator input to the other receivers and estimate the amplitudes of the displayed sinewaves. Ideally all receivers should have the same wave amplitudes. Note that some CADI receivers don't have quite enough gain to produce full screen sinewaves with an input of -54 dBm. (Due to gain differences in receiver amplifiers). If this happened then the normal procedure is to set all the receivers to have the same amplitude of displayed sinewave. (But the amplitude should be close to full screen.)

Adjustments:-

If the above tests indicate that you need to adjust either the “zero offsets”, or the gains, you will need to be able to access the potentiometers on the receiver boards. This can usually be done by only having one receiver board plugged in at a time. If you are using just 1 receiver, then set the dip switches on the receiver board to have this receiver be “receiver #1”. The receiver number (address) is set by the package of 4 dip switches labelled “S1”. For receiver #1 these are all OFF. Remember what the previous setting was because you probably want to reset this to its previous

receiver number after you finish calibration. You can also opt to have a display of only the 1 receiver output by editing the number of receivers in the LOCATION.INI file. This is not necessary but makes the display simpler. If using only 1 receiver the local oscillator signal from the DDS board will be input to one of the miniature connectors on the receiver board, and the 50 ohm termination must be put on the other miniature connector.

The calibration uses potentiometers R58, R59, R60, and R61 (don't adjust R57 which sets the reference level for the A-to-D conversion):-

Potentiometer R58 sets the "zero offset" for the "I channel".

Potentiometer R59 sets the gain for the "I channel"

Potentiometer R60 sets the "zero offset" for the "Q channel"

Potentiometer R61 sets the gain for the "Q channel".

8. GPS time routines

These routines are set up for the **Trimble** GPS satellite clock using the Acutime unit. There are two different procedures -A or B below- depending on your application:-

(A) If you just need to update the pc clock daily -which should be adequate for most applications- then in CADI.BAT add a line "GPS-PC_2" if the GPS clock is connected to serial port #2 (or GPS-PC_1 if it is connected to serial port #1). It is best to put this line after the tape backup lines in CADI.BAT because, if the pc clock is running very fast (gaining a lot of time), then you could get undesirable results if, when the pc clock is reset, it is reset to the previous hour. The tape backup takes so long that this won't happen. Of course you will need to have the appropriate GPS-PC# program in the CADI_EXE directory.

(B) More precise timing takes all time from the GPS clock instead of from the pc clock.

(i) Modify LOCATION.INI so that the line giving information about the GPS clock (see description of LOCATION.INI above) is either TC1 or TC2 instead of NO. The usual CADI arrangement would have a mouse connected to COM1 and the Trimble GPS connected to COM2 so the LOCATION.INI entry would be TC2.

(ii) Configure the ACUTIME unit for optimum timing. You should only need to do this once since the settings are retained if you have a backup battery connection. If you move the clock antenna to a different position then you need to do this again.

What you want to do is to not have the clock continuously determining the clock position, but to "fix" the position, and have the clock determine more precise times. The sequence of clock commands to do this is as follows:-

1/ Run TSIPCHAT -c2 (if the serial input is Com 2, otherwise run TSIPCHAT -c1)
 2/ You can type '?' to get a menu. Enter 's' to see how many satellites have been acquired by the clock. If it has not defaulted to this mode, set track mode to "high 8, best-4 fix" by entering <J>, then <cr>, <cr>, <y>. You need to wait until >4 satellites have been acquired before doing the next step in this procedure (enter <s> and see if the power levels for 4 (or more) satellites are <> 0.0). [To get a simpler, less active, screen display enter ^O (control capital O), then <n>, enter 7 <sp> 0 <sp> 5 <sp> 0 <cr>, <y>.]

3/After you have enough satellites and your position is well determined, set to "over-determined clock mode" by entering <q>, then <E>, then accept the defaults by entering 1 <cr>, 3 <cr>, 300 <cr>, 4 <cr>, <y>.

4/ You may also want to send the clock an "accurate position". This can be used for slight timing adjustment. See "command packet #31" in the Trimble "Smart Antenna Developer's Guide".

9. Oblique Incidence Sounding

To do oblique incidence sounding you need two CADIs with GPS clocks. Actually you don't need two complete CADIs: All you need at one site (the transmitter site) is a DDS board and Power Amplifier, and at the second site (the receiver site) you need a DDS board and receiver boards. The GPS time information is input to the CADIs via a "clock interface" (contact SIL about this).

For oblique sounding you would select the option "ObliqueIonog" (or "ObliqueAmpl") in the "!data processing" line of the mode definition file.

You need to configure the GPS clocks for optimum timing. See section "GPS time routines" in this manual.

The oblique sounding mode samples are triggered by the 1 sec pulse provided by the GPS clock. A typical 1 sec 'sample' for an ionogram is 8 pulses which are then FFT processed. Such a sample would be acquired on each frequency so an ionogram of 200 frequencies would take 200 seconds. This is obviously quite slow compared to an "untriggered" ionogram, so there is plenty of time for an ionogram plot while waiting for the next frequency to be transmitted.

Note that the first frequency is transmitted 1 second after " $t = 0$ ". This 1 second delay gives slow hardware time to respond. To facilitate this delay it was necessary to impose the condition that the repeat interval for an oblique mode must be a multiple of 5 seconds.

INDEX

.DEF, definition files, 3, 6, 9, 10
automatic gain control, (attenuator setting), 12
BACKUPLG, 5, 6, 18
Barker, 8, 11, 12, 20
CADLBAT, 2, 3, 4, 5, 8, 18, 20, 23
CADIRUN, 2, 3, 4, 5, 6, 7, 8, 12, 15, 18
CADISCHD.ULE, 2, 3, 6, 9, 18
CADITEST, 2, 7, 8, 12, 13, 15, 18, 20, 21
CLEANUP, 5, 6, 18
Complementary, 11
Data File Format, 16
FILESIZE, 5, 6, 18
GPS time routines, 3, 4, 8, 9, 11, 23
LOCATION.INI, 2, 4, 6, 7, 13, 18, 22, 23
MAKEFREQ, 13, 14, 18
NEWTAPE, 6, 14, 18, 19
Oblique Incidence, 11, 24
Operator Instructions, 19
PRESSKEY, 4, 5, 18
Receiver Calibration, 21
single, 11
threshold, 11, 16, 17