SECTION 4
OPERATING MODES AND INSTRUCTIONS

CONTENTS

List of Tables

List of Figures

GENERAL INTRODUCTION TO SECTION 4

Section 4 consists of three chapters. Chapter 1 contains a general description of various operating modes of the sounder, the background necessary to understand its operation, and reviews science and housekeeping data products made by the digisonde. Chapter 2 describes the operating procedures for the real-time console of the sounder, and Chapter 3 explains principles of remote commanding over the Internet connection.

CHAPTER 1

DIGISONDE OPERATING MODES AND DATA PRODUCTS

INTRODUCTION

401. Digisonde is a highly configurable scientific instrument that offers a variety of operating modes and corresponding data products. The basis of all its ionospheric sounding activities is a *measurement program*, a set of 20 operational parameters that specify one sequence of measurements performed by the DPS system to acquire remotely sensed information about the current state of the ionosphere and store the information in a raw data file. Such measurement program can be started manually by a keyboard command or, for the autonomous operations, triggered by the system clock in accordance with currently active *schedule*, a repetitive sequence of measurement programs.

402. The DPS can be programmed to perform a number of different types of measurements and switch between various schedules. The following types of scientific measurements are available for the digisonde operations:

1) Ionogram
   a) Vertical incidence (VI) Doppler ionogram,
   b) VI Doppler ionogram with multi-beam processing for detection of oblique echoes,
   c) VI Doppler ionogram with multi-beam processing and two frequency precision ranging,
   d) Oblique Incidence (bi-static) ionogram between two digisondes, and
   e) Fixed frequency Doppler measurement.
2) Drift measurement (detection of multiple echoes and evaluation of their source velocities).

In addition to the scientific measurements, digisonde conducts the following housekeeping activities:

3) Calibration of the receiver channels, and
4) Built-In Test (BIT) of system status.

403. This chapter describes the various operational modes of the sounder, and gives examples of data analysis and post-processing applied to collected raw data to produce science products.

DIGISONDE DATA PRODUCTS AND VISUALIZATIONS

404. Figure 4-1 shows an overview of the Digisonde data products. There are three kinds of data that Digisonde actually acquires in the real-time measurements, (1) ionograms, (2) drift records, and (3) housekeeping. The rest of data products are derived using data analysis software that runs autonomously on the AUX com-

puter. Arrows in the Figure 4-1 indicate data flow for derivation and display of the products. Each of the products in the Figure 4-1 is shown as a circle labeled with the appropriate file extension for the format(s) used to store the data. There are several legacy data formats that have been discontinued. Although they still can be selected in the measurement program specifications and software settings, their further use is not recommended. Further details on the data formats can be found in Section 6.

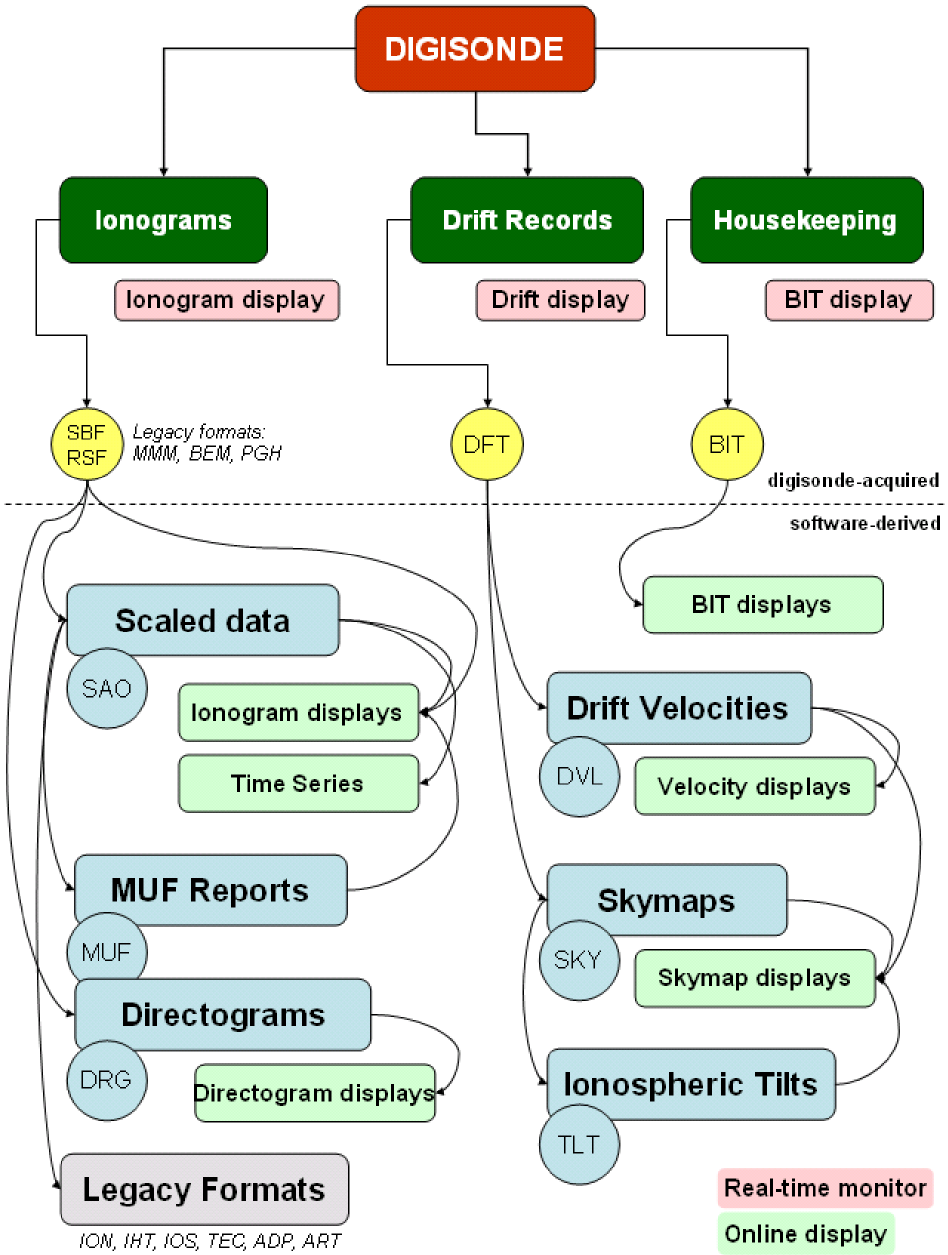

Figure 4-1: Overview of the Digisonde data products and displays

405. Figure 4-1 also indicates two kinds of displays available to the digisonde operator: (1) the real-time console of the MAIN computer showing measurement data as they are being acquired and (2) online data images that are made as soon as the derived data products become available. The online images are viewed by an Internet browser connected to the sounder's WWW homepage and can be visualized both over the Internet from remotely connected computers and locally at the station on the AUX computer screen.

406. An optically weighted font (Optifont) is frequently used by display software to denote signal amplitude by the 16 discrete levels of increasing pixel weight. The Optifont patterns are shown in Figure 4-2. Typically the signal amplitude is mapped to available 16 Optifont levels at 3 or 6 dB steps, resulting in 45 or 96 dB dynamic range of the presentation.

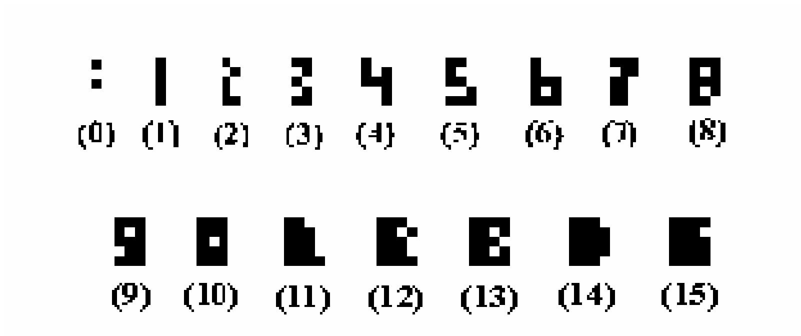

Figure 4-2 Optifont Characters Used to Represent Logarithmic Amplitude Steps

407. Adaptive thresholding and overflowing are used for ionogram displays to improve their appearance. For adaptive thresholding, a noise floor is detected for each frequency individually by finding the peak value in an amplitude distribution function, and all amplitudes below a given increment over the noise floor are excluded from the display. The overflowing technique normalizes amplitudes for display so that the maximum amplitude on each frequency is mapped to the Optifont level 15, which makes the ionogram traces look more consistent.

Real-time console screen displays

408. Figure 4-3 shows sample real-time console screen display produced by the DPS control computer in the ionogram mode. Menu options at the top bar of the screen are explained below in Chapter 2. The snapshot of this ionogram measurement was taken on October 30, 2006 17:40:14.730 UT. Upper two lines show program information:

A1	Program A ran as a part of schedule 1
DPH = R00	RSF ionogram, no printer, no post-processing
LLCUU = 01510	Start frequency 01 MHz, Coarse frequency step 50 kHz, Stop frequency 10 MHz
FS = 01	No fine stepping (i.e., one 0 kHz step)
X = 1	Complementary code waveform
A = 7	Antenna option set for multi-beam analysis
R = 1	100 pps repetition rate
N = 4	16 looks per frequency
HEM = 592	Height step 5 km, start height 90 km, 256 heights
IG = 28	Frequency search at 15 kHz steps, autogain enabled, base attenuation 0 dB
ig = 04	[Real-time search/gain data] quietest frequency 2 steps below nominal, optimal gain 4

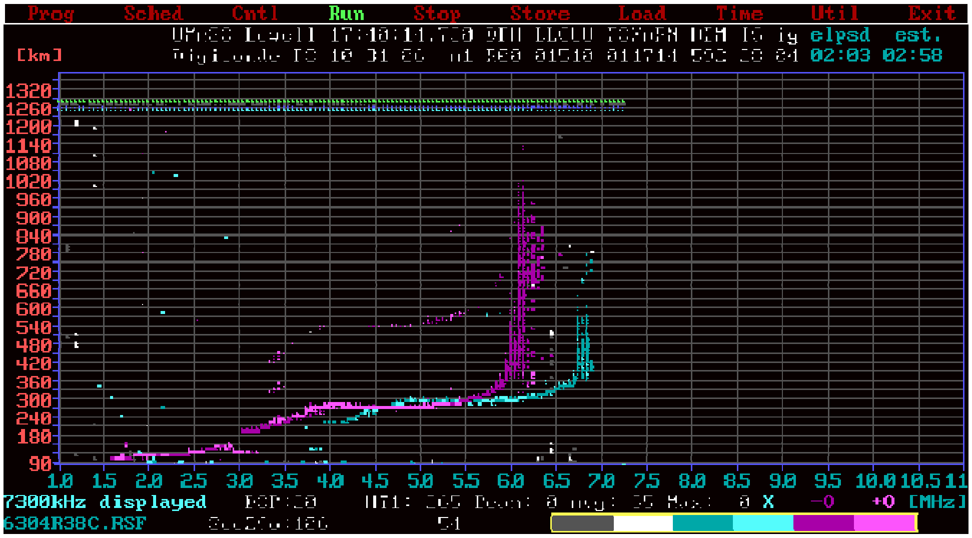

Figure 4-3: Real-time console display of an ionogram measurement in progress

Further details and recommendations on the program parameter selection can be found below in Chapter 2.

409. Figure 4-4 shows the real-time console screen display for a four frequency (S=4) drift measurement. The first four vertical height profiles (in red) show echoes for the four different frequencies coming from 270 km (referenced to the axis in km on the left side). The next four vertical strips show the contents of the 128-point Doppler spectrum (N=7) at the height of maximum echo amplitude (referenced to the axis in Hz on the right side).

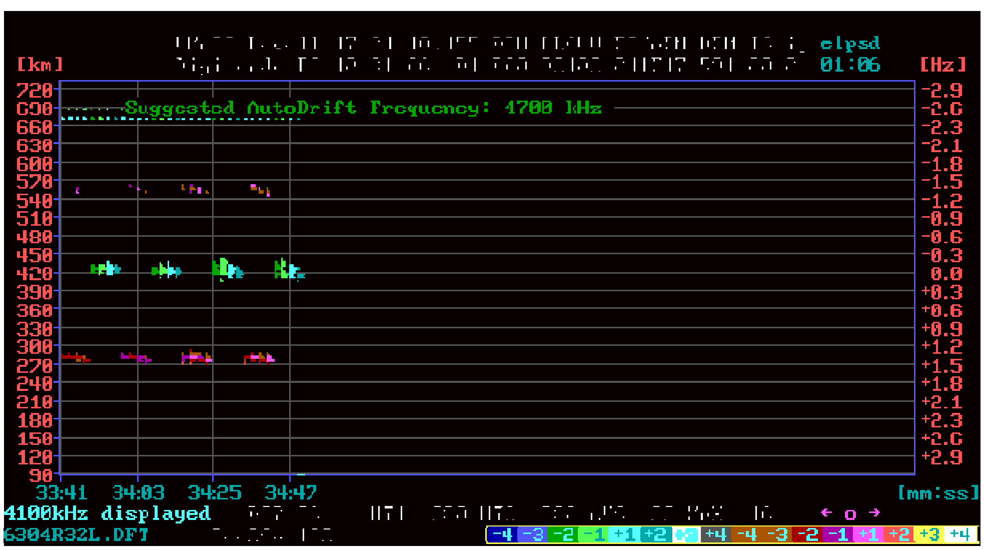

Figure 4-3: Real-time console display of a drift measurement in progress

Online displays

410. The ionogram online display (Figure 4-4) combines the ionogram data in the SBF or RSF format with the ARTIST-derived ionospheric characteristics, NHPC-calculated profile of the electron density plasma, and table of the maximum usable frequencies (MUF) obtained for a pre-specified list of distances. The table of autoscaled characteristics include confidence level of the autoscaling ranging from 55 (low confidence) to 11 (high confidence), as well as the version of the ARTIST software used to obtain the scaled data.

411. The concept for assigning colors to echo directions for ionograms is explained in Section 1, Chapter 1. The insert in Figure 4-4 summarizes the mapping and provides direction codes used in the color legend.

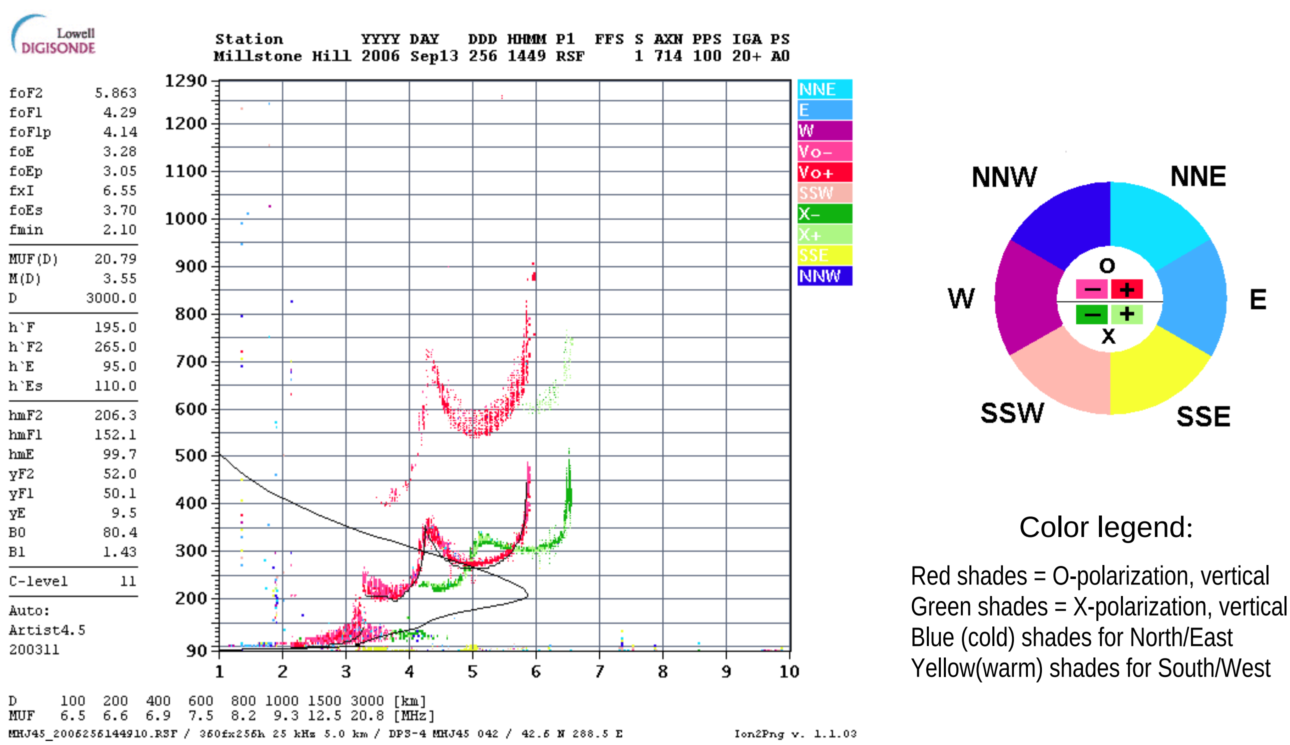

Figure 4-4 Typical ionogram display produced by Ion2PNG software for online visualization

407. The skymap display (Figure 4-5) combines the skymap of ionospheric echoes calculated by the DDAS software with velocity of the bulk motion of the ionosphere obtained by DDAV software and ionospheric tilt parameters derived by the TILT software. Each automatically detected source (echo) is processed to evaluate its angle of arrival, as explained in Section 1, and placed at the appropriate location of the skymap using + symbol for positive and o symbol for negative Doppler velocity. The bulk Doppler velocity is indicated in the Figure 2-7 as the triple tick marks indicating the azimuth and two labels showing horizontal and vertical components of the velocity in m/s. The ionospheric tilt is described on the skymap display in terms of the zenith and azimuth angles of the gravity center of all detected sources.

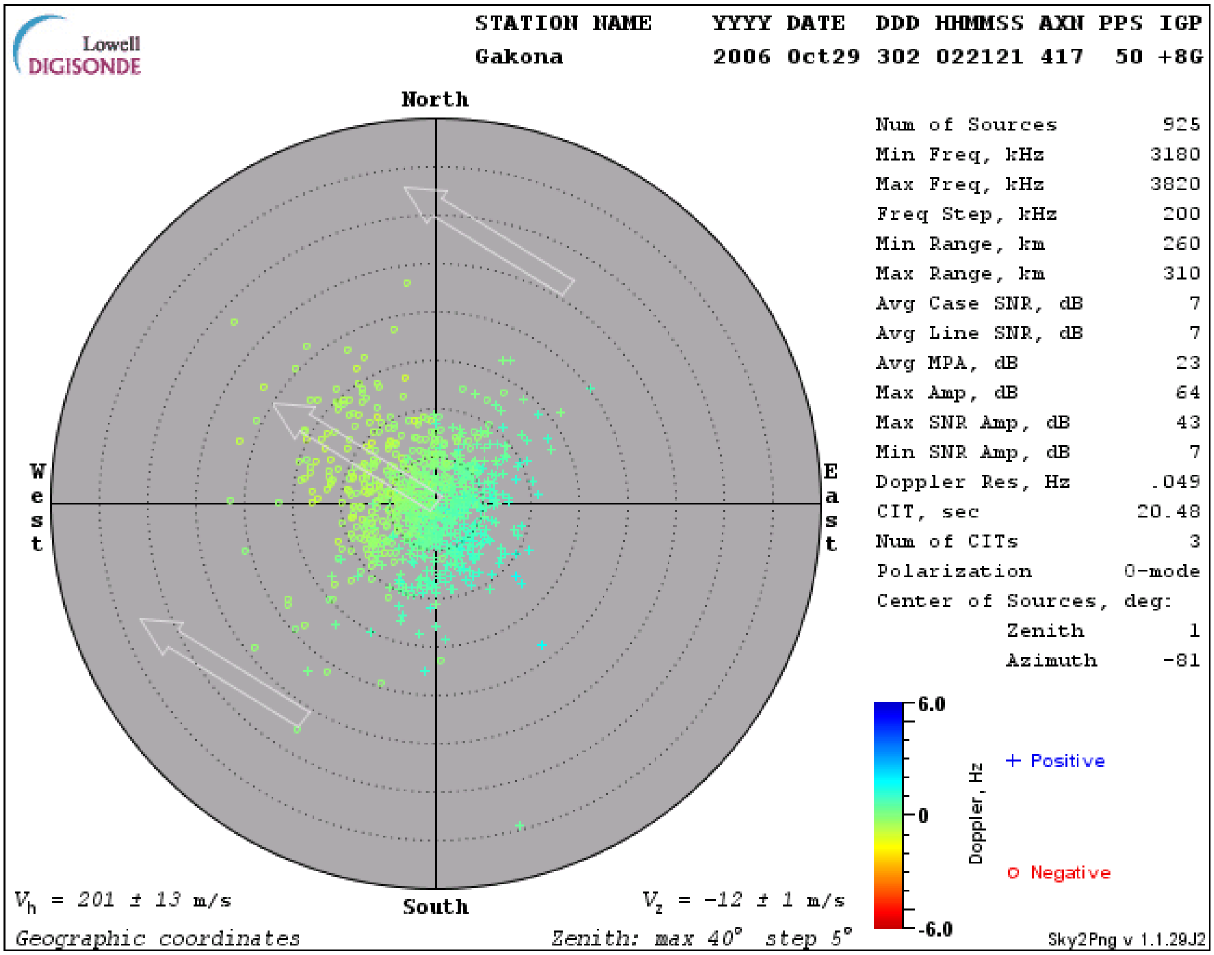

Figure 4-5 Typical skymap display produced by Sky2PNG software for online visualization

408. Digisonde visualization software offers three types of online displays that plot the daily time history of acquired data, (1) directogram, (2) drift velocity plot, and (3) time series of ionospheric characteristics.

409. The directogram display is useful to view large-scale plasma irregularities as they drift across digisonde location. It uses RSF ionogram data to derive ground distances to the plasma structures responsible for the oblique echoes in the ionograms and then to plot them using direction, Doppler, and amplitude information of the echoes. The left panel of Figure 4-6 presents a sample directogram plotted Drg2PNG software using one day of RSF ionograms collected at Jicamarca, Peru. Each horizontal line of the directogram represents one ionogram measurement, with time going downwards. There are two vertical panels, with left panel corresponding echoes arriving from west, northwest and southwest, and right panel for echoes from east, northeast and southeast. The central line between the panels corresponds to the vertical reflection at zero zenith angle. The directogram on Figure 4-6 does not show much activity between 10:00 and 24:00 UT, at which time passing day-night terminator causes generation of several ionospheric disturbances traveling east. Shades of blue in the directogram correspond to general direction of plasma drift from west to east, and shades of red are used to represent drift in the opposite direction from east to west.

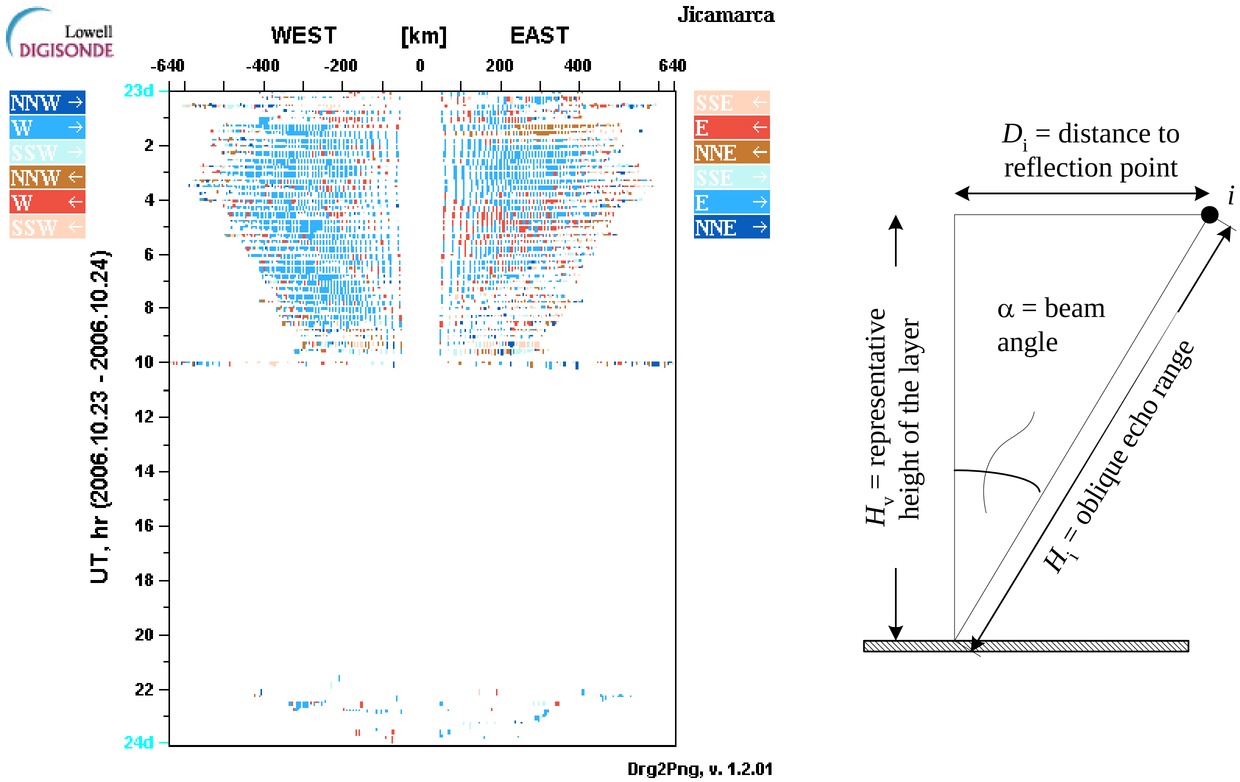

Figure 4-6: Daily directogram. (Left panel) sample directogram made by Drg2PNG software, (right panel) calculation of distance to the reflection point, D_i

410. The right panel of Figure 4-6 illustrates calculation of the ground distance to the reflection point that is plotted along the x axis on directograms. Ground distance to the reflection point, D_i, is calculated individually for each oblique echo range H_i corresponding to a plasma structure:

$$D_i = \sqrt{H_i^2 - H_V^2}$$

where H_v is a representative vertical height of the F layer that is estimated from the ionogram by locating the section of the vertical incidence F trace where amplitudes are high and height gradient is low. When manually scaled trace is available, hminF can be used reliably as H_v. For the autoscaled data, more consistent results are obtained by calculating summary amplitudes for each ionogram height and selecting H_v as the height of the highest summary amplitude.

411. History plots of the bulk plasma drift characteristics over the digisonde location are useful for detecting and evaluating large-scale plasma motion events, such as development of the Equatorial Spread F. Two separate panels are available for plotting drift velocity of E and F regions, as shown on Figure 4-7.

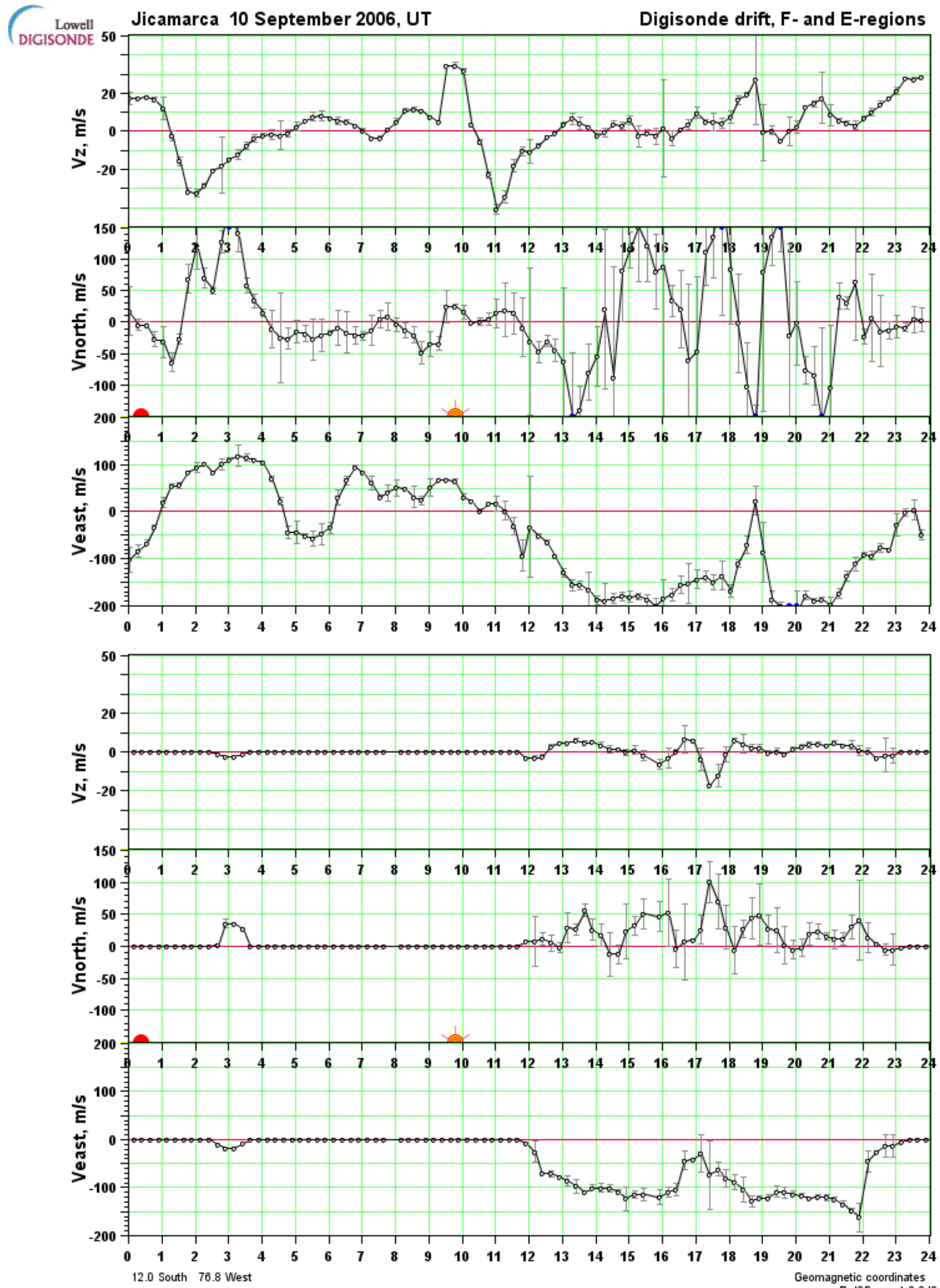

Figure 4-7 History plot of bulk plasma motion velocity for F (upper 3 panels) and E (lower 3 panels) regions of the ionosphere made automatically by Dvl2PNG software for online visualization.

412. The digisonde's web server can be used to scan local archive of SAO files maintained automatically by the digisonde to plot time series of ionospheric characteristics obtained by ARTIST software. Figure 4-8 shows a sample of the times series plot of critical frequencies foF2, foF1, foE, and their IRI predicted values. Time series plots are not produced autonomously as other online displays, but rather by request of the user.

Figure 4-8 Time series of ionospheric characteristics obtained using local archive of SAO files.

413. Housekeeping data are collected prior to each digisonde measurement, consisting of hardware sensor readings, software messages, and other derived system status information. Figure 4-9 shows a sample of the Built-In Test printout where a failed component is shown in red. A detailed explanation of the housekeeping modes can be found in Section 7.

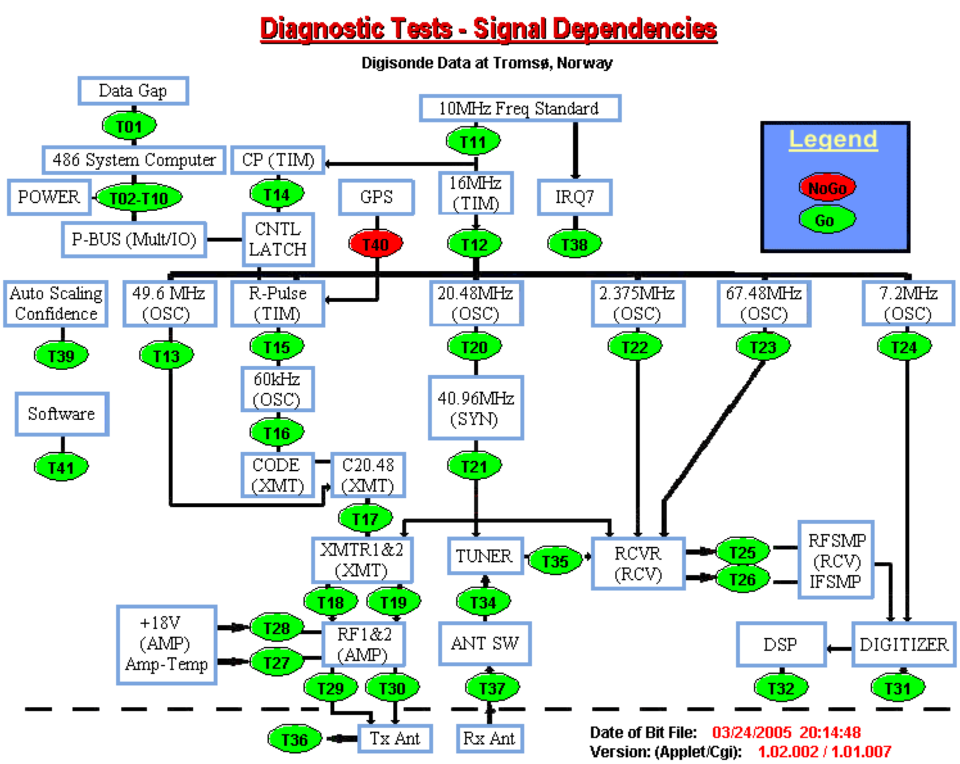

Figure 4-9 Sample plot of the digisonde Built-In Test (BIT) results.

DIGISONDE OPERATIONS IN VERTICAL INCIDENCE IONOGRAM MODE

414. It is possible to record four different types of VI ionograms:

a) VI Doppler ionogram,

b) VI Doppler ionogram with multi-beam processing for detection of oblique echoes,

c) VI Doppler ionogram with multi-beam processing and two frequency precision ranging, and

d) Fixed frequency high resolution Doppler measurement.

Refer to Section 1, Chapter 2 for general background information on the VI ionogram mode.

Doppler Ionogram with O/X Detection

415. In this simplest VI ionogram mode, Figure 1-15 of Section 1, detected echoes are characterised by the amplitude, polarization, and Doppler shift. This measurement type is invoked when a frequency range is specified (rather than a fixed frequency measurement), the antenna parameter (the "A" parameter) is set to 0 for forming an overhead beam, and the disk output parameter (parameter D) is selected as S (single byte format, SBF). For the VI mode, the outputs of the four receivers are summed digitally which tends to reduce or cancel signals received from off-vertical directions.

416. At each frequency, N number of pulses are transmitted, and M (128, 256 or 512) echo samples are made at a resolution of H (2.5, 5 or 10) km. After the echo from the last pulse has been digitized an N-Point Doppler spectrum at each height is computed in the DSP. The resulting Doppler spectra at each height are searched for a maximum, and the amplitude and Doppler line # of that maximum is recorded for each height.

417. During the transmission and sampling of the N number of pulses the receiver antennas are switched from O to X polarization (respectively, left hand to right hand circular in the Northern Hemisphere, and opposite in the Southern) from pulse to pulse. The Power Card (POW) applies the operating voltage to the receive loop antennas in the 4 element antenna array, routing it through the Antenna Switch (AntSw) at the rear of the DPS main chassis, where it is applied to the center conductor of the coax cable that connects the DPS to the receive antennas. The electronic switch in the pre-amplifier box on the loop antennas switches polarization of the antennas from pulse to pulse based on the voltage level (which switches between 16 and 22V) of the DC power carried on the center conductor of the coax cable. This allows effectively simultaneous measurement of the signal amplitudes at each polarization, while requiring that 2N pulses are transmitted since the N number of O pulses and N number of X pulses are interlaced, and the receiver can only process one polarization at a time.

418. The wideband received signal from the four receiving antennas is buffered in a preamplifier right at the base of the receiving antenna element, and transmitted via coaxial cable to the antenna switch where, in this VI mode, the signals are summed in phase in an analog combiner to create a vertical receiver antenna beam. This enhances the echoes from the overhead direction by 6 dB which effectively suppresses noise and interference arriving from oblique directions.

419. In the SBF data format, both O and X records are stored in the output ionogram file.

Doppler Ionogram with Multi-beam Analysis and O/X Detection

420. In this type of measurement the directions of received signals are evaluated in addition to Doppler frequencies and polarization. Since the DPS-4 has four receivers, signals from all four receive loops are received and forwarded for processing. In the Multi-beam mode the four receiver outputs are shifted in phase and summed to form six off-vertical beams as well as one overhead beam. This measurement format is invoked if

the antenna parameter (A) is specified as 7 or 15, and the disk output parameter (D) is specified as R. See Chapter 1, Section 2 for further discussion of digital beamforming and Figure 1-2 for a sample of the multi-beam VI ionogram.

Doppler Ionogram with Multi-beam Analysis and Precision Group Height (PGH)

421. A detailed explanation of the PGH mode is contained in Section 1, Chapter 2. PGH mode is used in sounding operations that require high accuracy of group height measurements. Figure 4-10 shows an example of the PGH ionogram displayed by the SAO Explorer software.

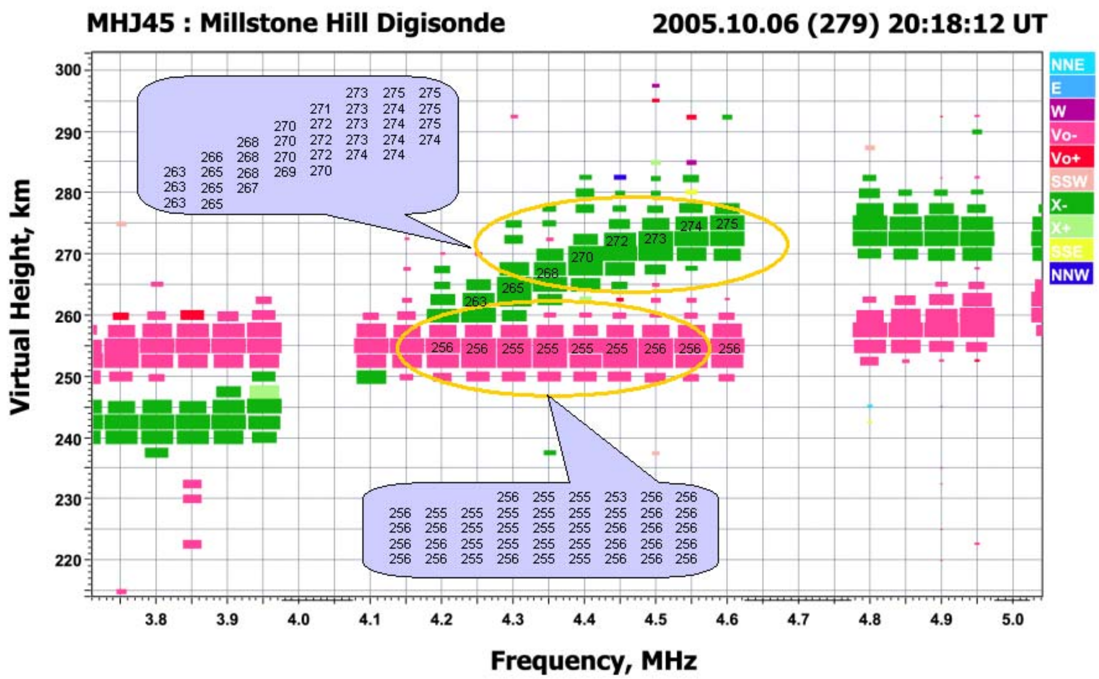

Figure 4-10: PGH ionogram display showing precision ranging data with 1 km accuracy

422. The PGH mode can be applied in either a stepped frequency ionogram or a fixed frequency ionogram. The sounder menu must be set up to multiplex two frequencies (S = 2) separated by 5 kHz (F = 5) in order for the PGH mode to work properly. The output format parameter must also select RSF (D = R).

HIGH DOPPLER RESOLUTION BY FREQUENCY MULTIPLEXING

423. In this mode the sounder features an enhanced sensitivity to existing Doppler variations. This is achieved by multiplexing several frequency steps (e.g. two or four) to widen the spread of color-coded Doppler indicators. This slows the effective pulse repetition rate per frequency, therefore, for the same number of pulses integrated the integration time is increased, which in turn increases the Doppler resolution. However, since several frequency steps are measured at the same time, there is no overall loss in measurement speed. The end result as well as the measurement time is not much different than a normal VI Ionogram Mode with the upper and lower frequencies set to the same value.

424. The enhanced Doppler resolution achieved is simply the inverse of the CIT. This can be calculated by multiplying all the selected multiplexed hardware configurations (combinations of antenna, frequency, code waveforms, and polarization) times the basic pulse rate of 50, 100, 200 Hz selected in the program. For instance, when measuring two polarizations, using the complementary code pair, integrating four frequencies simultaneously, making a 64-point (N = 6) Doppler spectrum at a pulse rate of 100 Hz requires:

2*2*4*64*0.01 sec = 10.24 sec

which results in about 0.098 Hz Doppler resolution. Since the Doppler spectrum is ±32 lines, the Doppler range is ±32 times the 98 mHz, or ±3.125 Hz. This set of parameters would allow the sounder to display a different color for each 0.1 Hz Doppler shift variation.

DIGISONDE OPERATIONS IN DRIFT MODE

423. The concept of Drift Mode measurements is explained in Section 1. In this mode the sounder stores complete high-resolution Doppler spectra for all four receiver channels over long periods of time, so that they can be used for produced data volume becomes a consideration. The data can be used for super-resolution direction-finding with a very effective isolation of multiple sources in the ionosphere with subsequent analysis of their velocities. In order to reduce the overall data flow, drift measurement operates simultaneously on selected number of fixed frequencies and stores spectra for an automatically selected subset of all ranges. Nominally, four frequencies and 8 heights are recommended (see example of Program D in Chapter 2), but up to 16 frequencies and up to 128 heights can be configured. It should be noted here that the sounder has to use Digisonde Drift Analysis (DDA) software to compute and display angles of arrival along with the 3-dimensional position and velocity (speed and direction of motion) of plasma features. The DDA software is available as the online version for autonomous calculations of the skymaps and drift velocity plots, as well is incorporated with the interactive analysis tool, Drift Explorer. The Drift Explorer software is available for download at the UMLCAR homepage, http://umlcar.uml.edu/downloads.html.

419. Select the Drift mode by entering D or F in parameter 16 (DISK_IO) of a program menu and setting the antenna parameter “A” in scanning mode (parameter 6 = 7 or 15). The measurement progresses by making a coherent Doppler integration of pulse echoes at each antenna. A Doppler spectrum is computed at each height sampled, then the entire Doppler spectrum at the heights selected by the O, B and T program parameters (from one to M, that is all, heights can be stored, centered on the height containing the maximum echo amplitude). The Drift modes (D = D or D = F) are the only way to get the sounder to store the entire Doppler spectrum from the echo heights, all other modes select a single amplitude from each Doppler spectrum before storage or display.

420. The DDA program, after screening the data with several quality and consistency checks, uses the four recorded phases (one for each antenna) at each of the Doppler lines to compute a 2-dimensional angle-of-arrival map (a “skymap”) for each height recorded. Doppler integration times of 10 to 40 seconds are usually sufficient to ensure that each Doppler line contains only a single source component, but a consistency check using the fourth antenna can detect and exclude points resulting from a non-planar wavefront.

421. Echo locations can be accumulated on the plot for a selectable period of time, but too long a time may obscure some of the short term phenomena being observed such as that shown in Figure 4-6. The top frame shows six frames of skymap data showing five minutes collection of echoes (integration of the image) from four heights and four frequencies all plotted together. While the six frames below it show the skymap from the maximum amplitude echo height after each coherent integration (20 sec). The east-west separation of echo locations with positive Doppler (Blue) in the West and negative Doppler (Red) in the East suggests an Eastward

drift of North-South aligned corrugations due to plasma plumes which are typically created after sunset at the equator. This motion continues for several hours. The North-South alignment of the structure suggests that field-aligned irregularities are experiencing a uniform electric field driven (vertical E) drift common at equatorial latitudes.

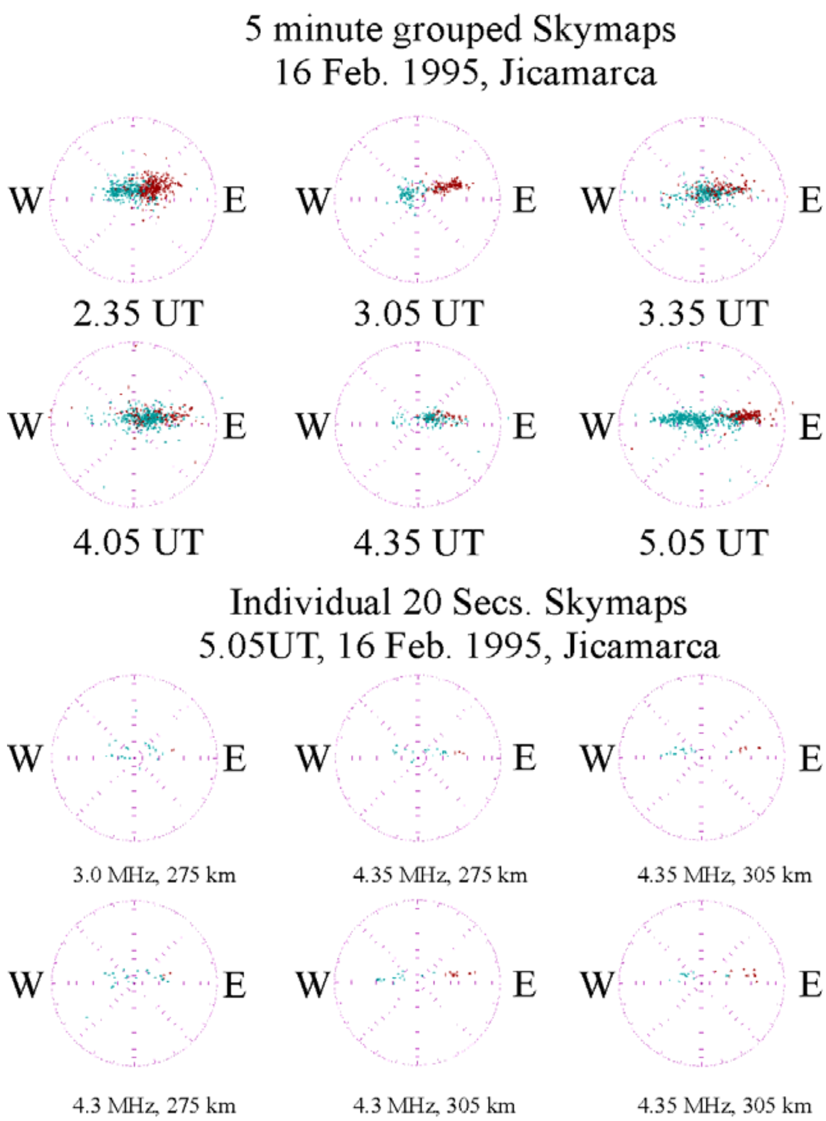

Figure 4-6 Five Minute Versus 20 Second Skymap Image Integration

422. In a very dynamic ionosphere, such as found in the auroral and polar regions, there may be many moving structures at the same height (or range) which are spread out across the sky. This can produce several Doppler lines representing different moving surfaces as shown in the stack of Doppler spectra in Figure 4-7. The Doppler shifts of about 3 Hz, represent radial velocities of about Mach 1, or 330 m/sec.

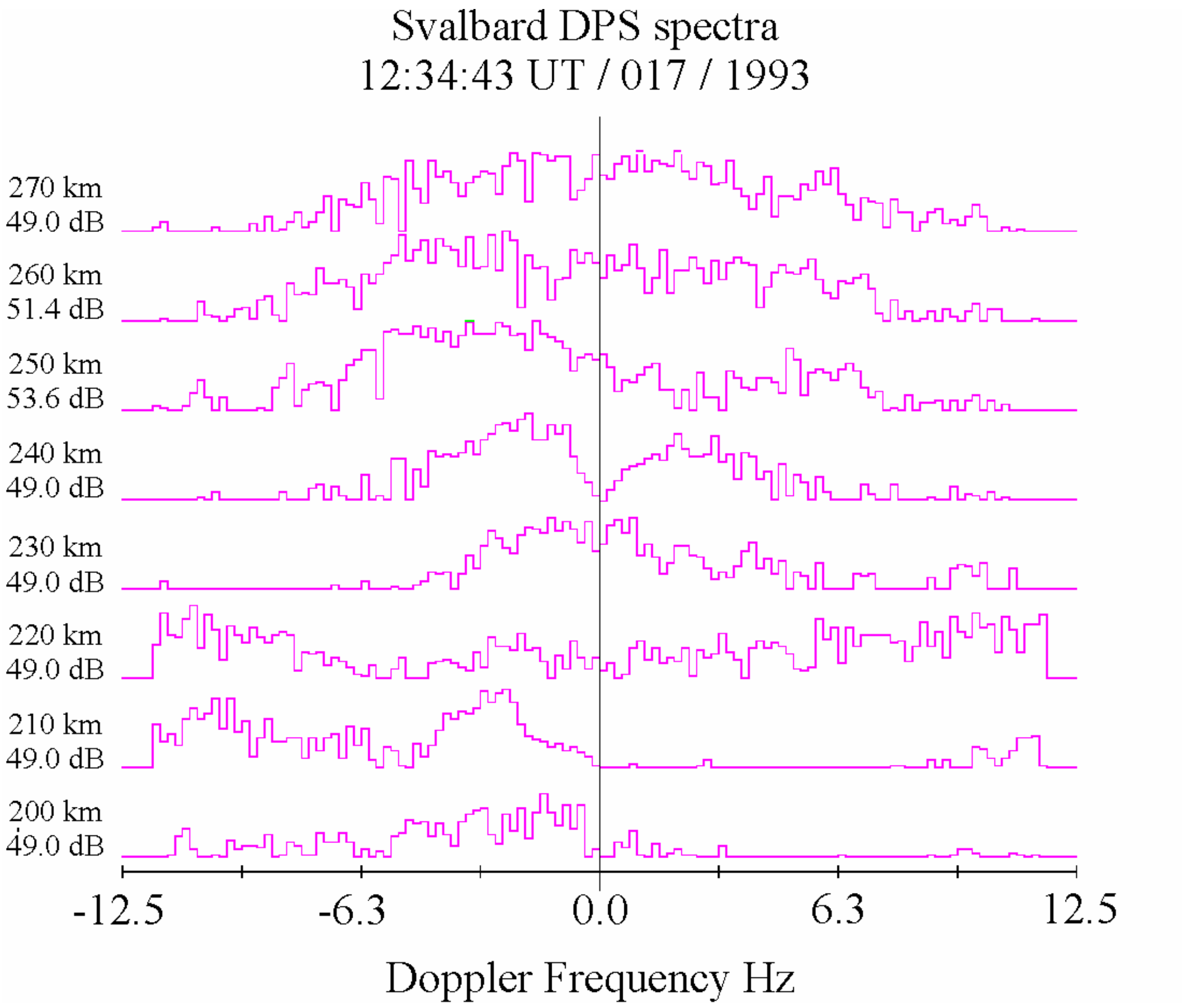

Figure 4-7 Vertically Stacked Doppler Spectra, Svalbard Norway, 17 Jan 1993

OBLIQUE INCIDENCE CW (OR LONG-PULSE) WAVEFORM

425. The oblique measurement can be made using the complementary coded pulse waveforms. But since this is a bi-static operation, the transmitter can be active all the time at one end of the link and completely quiet at the other end. Conversely, in monostatic VI operation the transmitter has to shut off so the receiver can detect the echoes, therefore a pulse duty factor of 10% or less is necessitated. Using the 100% duty cycle waveform with the 127-chip M-code, adds almost 10 dB of signal power (same peak power level but longer duty cycle), so it is the preferred waveform for oblique incidence measurements.

CHAPTER 2

OPERATING INSTRUCTIONS

REAL-TIME CONSOLE

INTRODUCTION

428. The sounder contains two computers, MAIN and AUX(illiary) running in parallel. The MAIN computer runs the sounder control program (DPSCNTL.EXE) that interacts with the user via the real-time console of the sounder. The AUX computer has a master program which orchestrates a suite of processing and communications software to perform automatic scaling of ionogram data and distribute files in on-site storage locations as well as remote files servers via FTP (file transfer protocol).

429. DPSCNTL.EXE is a menu-driven program that operates the system either in unattended mode or manually. In unattended mode the software executes sounding programs according to the pre-defined schedule (program settings and schedules are read from a disk file PROGSCHD.DAT). In the manual mode the operator, using the command menu, is able to edit existing programs and schedules, and start them manually to run immediately. DPSCNTL.EXE is invoked automatically during the power-on stage, and displays the window shown in Figure 4-9.

Figure 4-9 DPSCNTL.EXE Initial Display Window (On Start Up)

430. At the top of the display is the Command Menu, below that the Control Window, the center is the Data Display Window. Each item is described as follows:

431. **Command Menu** – This menu is used in the manual mode of operation to control the system. Unless program or schedule parameters are being edited this menu is always available, though at times a right or left arrow must be pressed to see it. These are the Command Menu control choices:

Prog – Puts the current parameters for Program X (X is prompted for) on the screen for inspection and editing by keyboard entry.

Sched – Allows the user to view and/or change the current operating schedule by selecting which minute of the hour a given preset program will be executed.

Cntl – Allows the user to manually set the currently active program and schedule. The currently active program is the one which will be executed if the RUN command is selected; and the currently active schedule is the one which can now initiate any preprogrammed measurements.

NOTE

In order to manually set the currently active program, the active schedule in the CNTL menu must be set to zero or the scheduler will set the selection back to the next scheduled program. Be careful to set it back to the desired schedule if subsequent automatic operation is expected.

Run – Manually initiates execution of the currently active program.

Stop – Manually halts transmission after the current CIT.

Store – Allows the user to save the program, schedule and control information (i.e., the entire operating environment) to the disk using a file name entered by the user, to facilitate resetting previously used parameters.

Load The user may upload program, schedule and control information from a particular disk file previously stored with a unique name specified by the user.

Time This command allows manual change of the system time, including the software clock (to 5 msec accuracy) and the MAIN computer's battery powered hardware RTC (to the nearest second only). The software clock setting is followed automatically by synchronisation to an external 1-pps, if present, which forces the clock's milliseconds counter to agree with either the rising or falling edge of the 1-pps reference signal (rising or falling is selected by a jumper on the timing card). If a GPS receiver is available, the software clock will get the time from it.

Util – Allows access to the sounder's utility programs described in Section 6.

Exit Initiates an orderly exit from the entire system to the DOS operating system.

432. **Control Window** – Below the Command Menu is a condensed area describing the sounder's current operation status. The time, date, current schedule and current program are displayed (see Figure 4-10) along with a shorthand representation of the current program parameters.

```
CONTROL WINDOW FORMAT:
Producer            Time.msec (UTC)    Parameter Labels
System              Prog/Sched Date    Program Parameters

EXAMPLE CONTROL WINDOW:
UMass Lowell        20:45:15.185      DPH  LLCUU  FSXARN HEM   IG  ig
Digisonde PS        08/05/91  A2      S00  01122  011024 292   08  00
```

Figure 4-10 Example of Control Window With Typical Values

The time displayed is in UTC. The rapidly changing numerals displaying milliseconds are an important diagnostic indication of the successful conversion of the 16 MHz master oscillator (or optional 10 MHz rubidium oscillator source) to system timing signals; one of which is the 5 msec hardware interrupt which causes the control software to count time in 5 msec increments. Below the time is a letter followed by a number. The letter is the currently defined “active program” which will execute if you select the RUN command and the number is the currently active automatic schedule. Next is the date, which is self-explanatory. Continuing to the right are the current program parameters (discussed later in this chapter). The values are hexadecimal in some cases (i.e., 10 to 15 are represented as A to F) to allow the parameter to be represented by a single digit.

Items that may not be obvious are:

1) the representation of the R parameter by 5 = 50 Hz, 1 = 100 Hz and 2 = 200 Hz;
2) the S, D, F P, H, C or M for the disk parameter are not hexadecimal but abbreviations for the data output format;
3) an offset of 8 may be added to the defined values (and displayed in hexadecimal) which alters their meaning. See Section 6 for a description of parameter formats or see the help window at the bottom of the program editing screen (the Prog window).

The last two parameters, lower case **i** and **g**, are the dynamic result of the frequency search operation (showing candidate frequency 0 to 4 being selected) and automatic gain (showing the dynamically selected receiver attenuation setting, 0 to C defined as 3dB per unit) which are being used during the current CIT. The Control Window runs as a low-priority function of the main ( ) program loop, not in response to the 5 msec hardware interrupt, therefore updates are often halted or delayed.

Data Display Window – This area of the screen is normally used to display measurement data as the sounding proceeds. Figure 4-9 shows the Startup Screen where the data display window contains system status information, such as software version numbers, hardware configuration, and GPS status.

431. By default, after displaying the start up screen, DPSCNTL.EXE enters the unattended mode unless the active schedule is set to zero, which can be invoked manually in the CNTL window described above.

UNATTENDED MODE OF OPERATION

432. As implied, this mode does not require user intervention except to override it in order to switch to manual mode to change the program and schedule settings. The sounder continues to provide sounding data according the active schedule. See description of SCHED(ule) and CNTL(Control) under *Detailed Description of Command Menu Selections* below.

MANUAL MODE OF OPERATION

433. In this mode, the user controls the system by making a selection from the command menu at the top of the screen. Selection is made using the left arrow/right arrow keys on the keyboard. While in a menu editing mode, no transmissions can take place.

434. Any of the sounder's seven pre-programmable measurement programs may be set up to make any of the measurements described in Chapter 1 of this section. These measurements are set up using the Command Menu as described in the following paragraphs.

DETAILED DESCRIPTION OF COMMAND MENU SELECTIONS

Prog(ram)

NOTE

By selecting "Prog" from the menu, the user has chosen to view and/or edit an existing program. Prior to editing, the program will contain default values stored on disk as "PROGSCHD.DAT". Modification of program parameters results in automatically overwriting these default values. If the old values are to be saved, use the "Store" selection prior to any modifications.

435. Pressing the ENTER key while "Prog" is highlighted will select the Program Selection Screen shown in Figure 4-11. By convention the various letters have typical default applications, such as A for automatic ionogram measurements (e.g. each quarter or half hour), B for digital beamforming for directional information, F for fixed frequency and G for Drift (or goniometer) measurements. However, the measurement parameters in each program dictate the specific performance of the program and all programs allow the same parameter options, so the operator may set any program letter to perform any specific measurement function.

436. Select the desired program name to enter the corresponding Program Editing Screen (see Figure 4-12 on the following page) or press ESC to return to the Command Menu.

437. The program editing screen allows the user to edit the existing measurement parameters for the selected program (A-G). The 20 program parameters that can be changed are described in detail below.

438. Table 4-1 (on the following page) shows the acceptable range of program measurement (PM) parameters. The characters shown in the ABBR. column of the table appear in the Control Window of the main DPSCNTL.EXE screen.

```
Edit Program   A
Edit Program   B
Edit Program   C
Edit Program   D
Edit Program   E
Edit Program   F
Edit Program   G
```

Figure 4-11 Program Selection Screen

(L)	Lower Freq (kHz) 2000		(H)	Height Res (km)	2
(C)	Coarse Step	50	(M)	# of Heights	256
(U)	Upper Freq (kHz)	12000	(K)	Delay (1 = 50 msec)	0
(F)	Fine Freq Step (kHz)	5	(G)	Gain (0 to 15)	9
(S)	# Small Steps	1	(I)	Freq Search (0,1)	1
(X)	XMTR Waveform	1	(O)	# Output Hts	8
(A)	Antennas (0 = Beam)	0	(D)	Disk (0 S M D F P)	S
(N)	FFT Size (Power of 2)	5	(P)	Printer (BW, Color)	0
(R)	Rate (pps)	100	(B)	Bottom Ht	180
(E)	First Height (km)	90	(T)	Top Ht	640

Figure 4-12 Program Editing Screen Display (Example)

Table 4-1 PM Parameters

ITEM	PARAMETER	ABBR.	RANGE OF VALUES	[DEFAULT VALUE]
0	Lower freq	(L)	1000 to 40000 kHz	[2000]
1	Coarse step/ #Reps	(C)	5 to 200 kHz	[100]
2	Upper freq	(U)	1100 to 40000 kHz	[16 000]
3	Fine step	(F)	5 to 1000 kHz	[0]
4	Small Steps	(S)	–16 to +16 (negative values disable multiplex-ing)	[1]
5	Waveform	(X)	1 to 4	[1]
(Note: Adding 8 to this value disables the switching of interpulse phase)				
6	Antennas	(A)	0, 1, 2, 3, 4 or 7	[0]
(Note: Adding 8 to this parameter disables the switching of O/X polarization, choosing instead, O polarization only)				
7	FFT size	(N)	3 to 7 (power of 2)	[5]
8	Pulse Rep Rate	(R)	50, 100 or 200	[100]
(Note: Adding 8 to this parameter disables the transmitter so that synchronized bi-static reception is possible)				
9	First height	(E)	0 to 180	[90]
10	Height res	(H)	2.5, 5 or 10 km	[5]
11	Num heights	(M)	128, 256, or 512	[128]
12	Delay	(K)	0 to 20 000 (50 msec units)	[0]
13	Gain	(G)	0 to 7 (8 to 10 for automatic gain)	[9]
(Note: Adding 8 provides the same nominal gain setting but allows additional attenuation if the received signal is too strong, i.e., automatic gain)				
14	Freq Search	(I)	0 or 1 (0 = disabled, 1 = enabled)	[0]
15	Number of Heights to Output x2	(O)	2 to 128	[8]
16	Disk IO	(D)	0, M, S, D, F, P, H, R or C	[0]
17	Printer ON	(P2)	(obsolete)	[0]
18	Bottom Ht to Out-put	(B)	0 to 640 km	[90]
19	Top Ht to Output	(T)	30 to 2560 km	[640]

439. A further description of each parameter in Table 4-1 includes:

0 – **Lower Frequency Limit (L)**. The first frequency (Start Frequency) transmitted during a re-read frequency PM, or alternatively, the only frequency transmitted if a fixed frequency measurement is being made.

1 – **Coarse Frequency Step/# of Reps (C)**. The size of the frequency step (in kHz) to be made between frequency measurements. If Item 0 and Item 2 are equal, C is interpreted as the # of times to repeat a “fixed frequency” measurement.

2 – **Upper Frequency Limit (U)**. The last coarse frequency step in a stepped frequency PM. Setting this item the same value as item O(L) results in a fixed frequency PM.

3 – **Fine Frequency Step (F)**. During a CIT the frequency can be changed (multiplexing). Parameters 3 (F) and 4 (S) allow a multiplexed coherent integration to take place. The sounder alternates the sampling of received signals from one or four antennas (according to A) for as many as 16 frequencies and two polarizations (left or right hand circular), or any other combination of 128 or fewer configurations (for example, up to 128 frequencies from a single antenna and single polarization). Switching antennas, frequency and polarization is accomplished between pulses in the 200 msec period immediately before each pulse. The resulting sampled data from the receiver is then stored in separate data buffers such that a unique Doppler spectrum can be computed for each combination of antennas, frequency and polarization. This allows several advantages over integrating one frequency and one antenna at a time, e.g.,:

a. Higher Doppler resolution at each frequency step without sacrificing PM run-time. Since as many as 200 pps are transmitted, the Doppler range can be as high as ±100 Hz. However, by multiplexing eight frequencies and two polarizations (16 coherent buffers) the range is cut down to ±6 Hz with a corresponding 16 times increase in Doppler resolution.

b. Comparison of echo phase at two closely spaced frequencies in order to compute a very accurate height measurement using the D(phase)/D(frequency) technique, similar to multiple frequency step ranging used in high resolution radar.

c. Comparison of “simultaneously” sampled amplitude vs. polarization to determine signal polarization without having to contend with temporal variations due to signal fading.

d. Simultaneous measurement of phase on several antennas to determine direction of arrival, either by digital beamforming, correlation matrix technique or simple triangulation (interferometry). (Refer to Section 1 of the manual for a detailed description of multiplexing.)

4 – **Number of Small Frequency Steps (S)**. The absolute value of S sets the number of fine frequency steps in a CIT. If S is positive, all frequency steps are completed before making each subsequent time domain sample on the first frequency (i.e., multiplexed or interlaced). Therefore, the measurement at the various frequencies are made simultaneously. Making S a negative value flags the system to NOT MULTIPLEX, but complete the coherent integration at each frequency before changing frequency. This non-multiplexed or repeating mode provides a larger Doppler range since the period between time domain samples is minimized, and it allows a series of sequential measurements to be made.

5 – **Transmitter (Xmtr) Waveforms (X)**. The available waveforms are:

1. 8-chip complementary phase codes (533 μsec pulse).
2. 1 chip “simple” pulse (67 μsec).
3. 127 length maximal length sequence (75% duty cycle for oblique or bi-static measurements only).
4. 100% duty cycle M-codes (maximum 270 msec pulse).

1. **Normally the phase of each even numbered pulse is inverted to eliminate coherent interference at the carrier frequency ("interpulse phase code"). If 8 is added to the X value the sounder will run the PM with interpulse phase code disabled.**
2. **The maximal length sequence operates best with H = 5 or 10 (km), M = 256 or 128 (respectively), G = 8, I = 0 and D(16) = R. The combination of H = 5 and M = 128 will not allow the pulse compression to work properly.**

6 – **Antenna Configurations or Sequences (A)**. Four antenna elements are available, either to be selected individually or summed together to form a vertical or obliquely tipped beam. The six settings implemented are:

0 Antenna signals are summed (by an analog summing amplifier) into one vertical beam.

1–4 All samples are made on the specified single antenna (i.e., antenna 1, 2, 3 or 4).

5–6 (Not used)

7 Signals are sampled from all four antennas in rapid sequence in the single receiver DPS-1 systems, or and simultaneously with four receiver DPS-4 model.

NOTE

If 8 is added to any of the above described settings (i.e., 8–15), only O polarization is used. Otherwise, the transmit and receive antennas alternate from O to X polarization between pulses.

7 – **Number of Integrated Repetitions (N)**. A power of 2 defining the number of coherent samples going into each Doppler integration. This is the number of times the program scans through S fine frequency steps, 1 or 4 antenna steps, 1 or 2 polarization steps and 1 or 2 code modulation steps. See Program Examples below.

NOTE

It is consistently adhered to in any combination of program parameters that the number N specifies the number of time domain samples which go into the Doppler spectrum at each height (N time domain samples result in an N point frequency domain Doppler spectrum). Therefore if multiple selections of polarizations, antennas and frequencies are integrated in this interlaced fashion, N samples will be made in each setting, and the resulting echo samples will be stored and integrated in separate data buffers. This results in systematically independent Doppler spectra (nature may cause some correlation between the spectra, but the system does not) corresponding to each combination of polarization, antenna and frequency settings. For instance four antennas, four frequencies and four polarizations require 32N pulses to be transmitted (8N for the DPS-4 and 32N for the DPS-4 when using the Complementary code pairs), and 32 independent Doppler integration buffers for each height. If 256 height samples have been selected, this results in <u>8192</u> independent Doppler spectra being computed for each CIT.

8 – **Pulse Repetition Rate (R)**. The choices are entered in literal values, 50, 100, 200:

50 Hz
100 Hz
200 Hz

NOTE

If 8 is added to the R value, the entire PM will be run in radio silence mode (i.e., with the transmitter off). The resulting numbers 58, 108 and 208 do not change the actual pulse rate.

9 – **Range/Height Extension (E)**. This is the range/height in kilometres of the first sample made after transmission of each waveform.

10 – **Height Resolution (H)**. Sets the digitizer sampling period (2.5 km = 16.7 msec, 5 km = 33.3 msec, 10 kms = 66.7 msec). The actual waveform is not affected by H.

11 – **Number of Height Samples (M)**. The number of complex amplitude samples made after transmission of each waveform, possible values are 128, 256 or 512.

12 – **Precision Time Delay (D)**. This precision timing offset allows different programs to receive oblique transmissions from other locations with the correct time delay. The delay count entered is in units of 50 μsec/count.

13 – **Computer Selected Gain Control (G)**. Either fixed or automatic receiver gain can be selected. In manual mode (parameter value of 0 to 7). Gain setting is given in 6 dB steps (higher “G” numbers make lower gain). Adding 8 to the parameter value (values 8 to 15) will set the same nominal gain as before, plus an automatic correction of as much as +36 dB can be added to the selected nominal value. For instance, the base gain value for 10 is the same as the fixed gain of 2, making 12 dB less than the maximum possible gain available from the receiver.

Therefore, the automatically adjusted range would be –12 to –48 dB below maximum gain. At most locations, a program with 6 to 12 dB more attenuation should be run at nighttime, since daytime D-region absorption has disappeared.

14 – **Frequency Search Flag (I)**. The frequency search function scans the receiver through four additional possible frequencies, symmetric about the nominal frequency (in 10 kHz steps), before each CIT is initiated and selects the frequency which provides the least background noise.

NOTE

This mode is incompatible with bi-static measurements since the two sounders could select different frequencies.

15 – **Output (O)**. The O parameter only affects the output of Drift format data (D = D, F or C). O specifies two times the # of contiguous height samples to be stored on disk. Only **every other** sampled height is stored since the pulse resolution of 10 km makes data sampled at 2.5 or 5 km spacing two or four times redundant. The finer samples aid in the real time determination of the maximum height. Since an entire N-point Doppler spectrum is stored for each height, each antenna and each frequency step, the O parameter can considerably limit the amount of data stored by the system.

However, an entire scattering function (all ranges and all Dopplers) can be stored by making O = [the value of] M (parameter 11).

16 – **Data Storage Format for Disk Files (D)**. It should be noted that this parameter not only specifies a file format, but indicates the type of measurement being made and, in some cases, affects the type of pre-processing done to the data prior to storage. With D = M, a disk file will be created named DATETIME.MMM (e.g., 2015J30A.MMM for 1992 15 January, 9:30 a.m. UTC (see naming conventions in Section 6) and the results of the CIT will be written as the PM progresses. The 0, M, B, D, F, P, H, R, E or C represent:

0 **No output**.

S **Doppler Ionogram in SBF format.** (See Section 6 for the format).

R **Combined Doppler, Beamforming and PGH Ionogram in RSF Format.** (See Section 6 for the format).

D **Drift Data format.** A file which records the full Doppler spectrum (2^N points from parameter 8, described above) at the height of the maximum amplitude pulse and at the O-1 heights surrounding the height of the maximum echo (i.e. O/2 above and O/2-1 below the max). The stored values are sequentially arranged spectra of amplitudes (voltages) in an 8-bit logarithmic format of 0 to 96 dB in 3/8 dB steps (i.e., 0 to 255) followed by the N corresponding 8-bit phases (0 to 360° in 1.4° steps). (See file format specifications in Section 6). The first amplitude in each Doppler spectrum represents the most negative frequency while the last is the most positive.

F **Drift Data format With Automatic Frequency Selection**. This is identical to the D format but the fixed operating frequency is selected using the automatic ionogram scaling that is performed by the ARTIST program, if results are less than 15 minutes old. In this case the start and upper frequencies (parameters S and U) are both automatically set to $f_{min}F + ((f_oF2 – f_{min}F) / 3)$. If scaled ionogram data is not available, the operating frequency reverts to the entered value.

C **Calibration File.** This file is a D format file and thus stores the entire Doppler spectra. Selection of the C disk data format causes internal switches to be activated in the Antenna Switch to loop back a test signal for calibration purposes. The file created will be named RCVRCALØ.DFT, and is automatically copied to C:\DPSCNTL at its completion. Each time thereafter that DPSCNTL.EXE is executed it loads in these calibration values and from then on numerically corrects the phase and amplitude of the receiver outputs.

17 – Reserved.

18 – **BOTTOM_HT (B)**. In the Drift Data format (D parameter = D) parameter B sets the bottom height of the window to be searched for a maximum amplitude.

19 – **TOP_HT (T)**. Along with Item 18, this sets the window of heights from which data will be stored in the D = D, F or C.

440. Pressing the ESC key will exit this screen, store the edited values and return to command menu selections at the top of the screen. Notice that the time display at the top center of the screen is not updated if you are still in the editing mode.

Programming Examples

441. The operator should first design one coarse frequency step since the measurement program is simply a series of the same signal integration procedure at each course frequency step. This integration period, or frequency dwell will be referred to as a coherent integration time, or one CIT throughout this document. The CIT parameters chosen will affect Doppler ambiguity, Doppler resolution, signal-to-noise improvement and the ability to obtain direction of arrival or consistent phase vs. frequency data. For a slow moving mid-latitude ionosphere it is desirable to multiplex frequencies so that the coherent integration time is stretched out to about 10 seconds to obtain a high resolution (about 0.1 Hz) Doppler spectrum. Therefore, it is possible to chose to multiplex four frequencies (S = 4), four antennas (summed) beam (A = 0), two polarizations (any A < 8), and two codes (X = 1, for the Complementary Code pair) while transmitting at 200 pps (R = 200) and repeating the scan of code/frequency/ polarization 64 (N = 6) times to create a 64 line Doppler spectrum at each frequency. This results in 1024 pulses being transmitted per CIT. With M = 128 heights per height profile, 1024 x 128 height samples = 131,000 complex samples acquired and processed over a period of five seconds. The Doppler ambiguity would be ±6.25 Hz and Doppler resolution would be 0.2 Hz.

442. If four 50 kHz small steps (S = 50) were chosen, each CIT spans 200 kHz of the radio spectrum. Therefore, the coarse step size should be 200 kHz and for daytime F-layer studies a lower frequency limit could be 2 MHz (L = 2000) and the upper limit could be 14 MHz (U = 14 000) for a total of 60 CITs. If all F-region Doppler spectra are to be recorded a bottom to top range of 200 to 500 km (B = 200, T = 500) could be set and 32 heights (O = 32) stored around the maximum echo. To activate hard disk storage select D = D for drift measurement file format. These parameters will result in the storage of a 64-point Doppler spectrum for each of 32 heights, two polarizations and 240 frequency steps. Therefore, the data to be stored consists of 983 040 complex amplitudes requiring 1.966 Mbytes of storage space. As can be seen, fine frequency steps, large Doppler spectra and storage of all (or most) heights can easily result in very large data files.

f. The programs described in this paragraph are illustrations of parameter selections which will execute the following measurement objectives:

Program A		**Run_Time = 1.07 minutes**	
: (L) Lower_Freq (kHz)	1000	: (H) Height_Res (km)	2
: (C) Coarse_Step/# of Reps	50	: (M) # of Hghts (128/256)	256
: (U) Upper_Freq (kHz)	12000	: (K) Delay (1 = 50 μsec)	0
: (F) Fine_Freq_Step (kHz)	5	: (G) Gain (0 to 15)	9
: (S) # Small_Steps (+ or –)	1	: (I) Freq Search(0, 1)	1
: (X) Xmtr waveform (Comp = 1)	1	: (O) # Output Hts	8
: (A) Antennas (0 = beam)	**0**	**: (D) Disk (0SDFPCBR)**	**S**
: (N) FFT size (power of 2)	5	: (B) Bottom_Ht to Output	210
: (R) Rate (50, 100 or 200)	200	: (T) Top_Ht to Output	500
: (E) First height (km)	90		

Figure 4-13 Program Editing Screen (Typical)

<u>Program</u> **<u>Description</u>**

A Performs a Doppler ionogram which identifies ordinary (O) and extraordinary (X) wave modes, creates a MMM formatted output file. Figure 4-13 sets up such a program.

B Similar to Program A, but also performs digital beamforming thus providing O/X wave identification, as well as coarse direction of arrival determination.

C Performs a Precision Group Height ionogram that prints out two vertical lines on the ionogram for each CIT.

D Performs a Multiplexed or Non-Multiplexed Drift ionogram.

E Runs a calibration program.

F Performs an Oblique Scanning Transmission (requires a cooperating sounder at greater than 15 km range).

G Performs a multiplexed AUTODRIFT program that will automatically run after any program that has D = S, B or R parameters.

Program Options

PROGRAM A: DOPPLER IONOGRAM

Scans from 1 to 12 MHz, in 0.1 MHz steps. Auto-gain and Frequency Search is enabled.

: (L) Lower_Freq (kHz)	1000	: (H) Height_Res (km)	5
: (C) Coarse_Step/# of Reps	100	: (M) # of Hghts (128/256)	128
: (U) Upper_Freq (kHz)	12 000	: (K) Delay (1 = 50 μsec)	x
: (F) Fine_Freq_Step (kHz)	x	: (G) Gain (0 to 15)	8
: (S) # Small_Steps (+ or –)	1	: (I) Freq Search(0, 1)	1
: (X) Xmtr waveform (Comp = 1)	1	: (O) # Output Hts	x
: (A) Antennas (0 = beam)	**0**	**: (D) Disk (0SDFPCBR)**	**S**
: (N) FFT size (power of 2)	5	: (B) Bottom_Ht to Output	x
: (R) Rate (50, 100 or 200)	200	: (T) Top_Ht to Output	x
: (E) First height (km)	90		

Antennas = 0: sum antennas.
Disk = S: SBF output.

PROGRAM B: BEAMFORMING IONOGRAM

Scans from 1 to 12 MHz, in 0.1 MHz steps. Auto-gain and Frequency Search is enabled. VI sources will be separated from oblique sources.

: (L) Lower_Freq (kHz)	1000	: (H) Height_Res (km)	5
: (C) Coarse_Step/# of Reps	100	: (M) # of Hghts (128/256)	128
: (U) Upper_Freq (kHz)	12 000	: (K) Delay (1 = 50 μsec)	x
: (F) Fine_Freq_Step (kHz)	x	: (G) Gain (0 to 15)	8

: (S) # Small_Steps (+ or –)	1	: (I) Freq Search (0, 1)	1
: (X) Xmtr waveform Comp = 1)	1	: (O) # Output Hts	x
: (A) Antennas (0 = beam)	**7**	**: (D) Disk (0SMDFPCBR)**	**B**
: (N) FFT size (power of 2)	5	: (B) Bottom_Ht to Output	x
: (R) Rate (50, 100 or 200)	200	: (T) Top_Ht to Output	x
: (E) First height (km)	90		

Antennas = 7: Record each antenna signal individually.
Disk = B: Beam Form interpretation; MMM format.

PROGRAM C: PRECISION GROUP HEIGHT IONOGRAM

: (L) Lower_Freq (kHz)	1000	: (H) Height_Res (km)	5
: (C) Coarse_Step/# of Reps	100	: (M) # of Hghts (128/256)	128
: (U) Upper_Freq (kHz)	12 000	: (K) Delay (1 = 50 μsec)	x
: (F) Fine_Freq_Step (kHz)	**5**	: (G) Gain (0 to 15)	8
: (S) # Small_Steps (+ or –)	**2**	: (I) Freq Search (0, 1)	1
: (X) Xmtr waveform (Comp = 1)	1	: (O) # Output Hts	x
: (A) Antennas (0 = beam)	0	**: (D) Disk (0SMDFPCBR)**	**P**
: (N) FFT size (power of 2)	5	: (B) Bottom_Ht to Output	x
: (R) Rate (50, 100 or 200)	200	: (T) Top_Ht to Output	x
: (E) First height (km)	90		

Fine Frequency Step = 5: 5 kHz frequency step between coherent samplings for dPhi/dF.
Number of Small Steps = 2: Use two multiplexed frequencies.
Disk = P: PGH interpretation of MMM data format.

PROGRAM D: MULTIPLEXED DRIFT (EXAMPLE 1)

Multiplexed frequencies of 3.8, 4.1, 4.4 and 4.7 MHz. No Autodrift. Output window from 180 to 540 km.

: (L) Lower_Freq (kHz)	3800	: (H) Height_Res (km)	5
: (C) Coarse_Step/# of Reps	8	: (M) # of Hghts (128/256)	128
: (U) Upper_Freq (kHz)	3800	: (K) Delay (1 = 50 μsec)	x
: (F) Fine_Freq_Step (kHz)	300	: (G) Gain (0 to 15)	8
: (S) # Small_Steps (+ or –)	4	: (I) Freq Search(0, 1)	1
: (X) Xmtr waveform (Comp = 1)	1	: (O) # Output Hts	8
: (A) Antennas (0 = beam)	**15**	**: (D) Disk (0SMDFPCBR)**	**D**
: (N) FFT size (power of 2)	7	**: (B) Bottom_Ht to Output**	**180**
: (R) Rate (50, 100 or 200)	200	**: (T) Top_Ht to Output**	**540**
: (E) First height (km)	90		

Antennas = 15: Scan each antenna, individually (7); disable X-polarization (+8).
Disk = D: Direct use of user-supplied Lower and Upper frequencies, DFT format.

PROGRAM D: NON-MULTIPLEXED DRIFT (EXAMPLE 2)

Successive frequencies of 3.8, 4.1, 4.4 and 4.7 MHz. AutoDrift disabled. Output window from 180 to 540 km.

: (L) Lower_Freq (kHz)	3800	: (H) Height_Res (km)	5
: (C) Coarse_Step/# of Reps	8	: (M) # of Hghts (128/256)	128
: (U) Upper_Freq (kHz)	3800	: (K) Delay (1 = 50 μsec)	x
: (F) Fine_Freq_Step (kHz)	300	: (G) Gain (0 to 15)	8
: (S) # Small_Steps (+ or –)	**–4**	: (I) Freq Search (0, 1)	1
: (X) Xmtr waveform (Comp = 1)	1	: (O) # Output Hts	8
: (A) Antennas (0 = beam)	**15**	**: (D) Disk (0SMDFPCBR)**	**D**
: (N) FFT size (power of 2)	7	: (B) Bottom_Ht to Output	180
: (R) Rate (50, 100 or 200)	200	: (T) Top_Ht to Output	540
: (E) First height (km)	90		

Number of Small Steps = –4: four frequencies (4); successive, or non-multiplexed (–).
Antennas = 15: Scan each antenna, individually (7); disable X-polarization (+8).
Disk = D: Direct use of user-supplied Lower and Upper frequencies, DFT format.

PROGRAM E: INTERNAL CALIBRATION (EXAMPLE 1)

For the DPS-4 internal switching of XMTR signal into antenna-input box, to be fed directly to the receiver(s). Frequency range of 1 to 15 MHz, in 1 MHz steps.

: (L) Lower_Freq (kHz)	1000	: (H) Height_Res (km)	2
: (C) Coarse_Step/# of Reps	**100**	: (M) # of Hghts (128/256)	256
: (U) Upper_Freq (kHz)	16000	: (K) Delay (1 = 50 μsec)	x
: (F) Fine_Freq_Step (kHz)	X	: (G) Gain (0 to 15)	1
: (S) # Small_Steps (+ or –)	1	: (I) Freq Search(0, 1)	1
: (X) Xmtr waveform (Comp = 1)	1	**: (O) # Output Hts**	**1**
: (A) Antennas (0 = beam)	15	**: (D) Disk (0AMDFPCBR)**	**C**
: (N) FFT size (power of 2)	5	**: (B) Bottom_Ht to Output**	**10**
: (R) Rate (50, 100 or 200)	100	**: (T) Top_Ht to Output**	**30**
: (E) First height (km)	**0**		

First Height = 0: Sample transmitted wave-form.
Output Heights = 4: Will store two heights, at 0 and 10 km (based on Height Res).
Disk = C: Calibration mode (signals switching of XMTR signal); stored in standard DFT format.
Bottom Height = 0: Window includes transmitted signal.

PROGRAM E: EXTERNAL CALIBRATION (EXAMPLE 2)

For calibration testing of antenna preamplifiers, antenna cables, antenna switch or antenna input box (DPS-4) receiver(s). A cable needs to be run from the XMTR1 BNC, on the from panel of the main chassis, through an attenuator, out to the antenna field. Output file may be read back by SHOWDFT to investigate phase and magnitude variations between antenna channels.

: (L) Lower_Freq (kHz)	1000	: (H) Height_Res (km)	2
: (C) Coarse_Step/# of Reps	100	: (M) # of Hghts (128/256)	256
: (U) Upper_Freq (kHz)	16000	: (K) Delay (1 = 50 μsec)	X
: (F) Fine_Freq_Step (kHz)	X	: (G) Gain (0 to 15)	1
: (S) # Small_Steps (+ or –)	1	: (I) Freq Search(0, 1)	0
: (X) Xmtr waveform (Comp = 1)	1	: (O) # Output Hts	1
: (A) Antennas (0 = beam)	15	: (D) Disk (0AMDFPCBR)	D
: (N) FFT size (power of 2)	5	: (B) Bottom_Ht to Output	10
: (R) Rate (50, 100 or 200)	100	: (T) Top_Ht to Output	30
: (E) First height (km)	0		

First Height = 0: Sample transmitted signal.
Disk = D: Store standard drift (disable internal switching of XMTR into Antenna box).
Bottom Height = 0: Window includes transmitted signal.

PROGRAM F: OBLIQUE (RADIO SILENT MAXIMAL LENGTH) SCANNING TRANSMISSION

Transmits maximal length code (127-chip), starting transmission based on precision GPS time. Receiving station requires identical program parameters (may need Delay parameter adjusted according to distance between stations), except that Rate need a +8 to disable transmission.

: (L) Lower_Freq (kHz)	1000	: (H) Height_Res (km)	5
: (C) Coarse_Step/# of Reps	100	**: (M) # of Hghts (128/256)**	**128**
: (U) Upper_Freq (kHz)	20 000	: (K) Delay (1 = 50 μsec)	0
: (F) Fine_Freq_Step (kHz)	x	: (G) Gain (0 to 15)	8
: (S) # Small_Steps (+ or –)	1	**: (I) Freq Search(0, 1)**	**0**
: (X) Xmtr waveform (Comp = 1)	**3**	: (O) # Output Hts	x
: (A) Antennas (0 = beam)	0	**: (D) Disk (0AMDFPCBR)**	**M**
: (N) FFT size (power of 2)	5	: (B) Bottom_Ht to Output	x
: (R) Rate (50, 100 or 200)	**50**	: (T) Top_Ht to Output	x
: (E) First height (km)	60		

Xmtr Waveform = 3: Maximal length code.
Rate = 50: Maximal length code requires a 50 Hz pulse-repetition rate. Receiving station will need Rate = 58.
Number of Heights = 128: Use 127 chip code (256 results in using 254 chip code).
Frequency Search = 0: Must be disabled since Frequency search is not a precision-timing function.
Disk = M: Store data in MMM format.

PROGRAM G: MULTIPLEXED AUTODRIFT

Program G is triggered, by the Disk parameter being set, to run immediately after any scheduled program.

: (L) Lower_Freq (kHz)	3800	: (H) Height_Res (km)	5
: (C) Coarse_Step/# of Reps	8	: (M) # of Hghts (128/256)	128
: (U) Upper_Freq (kHz)	3800	: (K) Delay (1 = 50µsec)	x
: (F) Fine_Freq_Step (kHz)	300	: (G) Gain (0 to 15)	8
: (S) # Small_Steps (+ or –)	4	: (I) Freq Search(0, 1)	1
: (X) Xmtr waveform (Comp = 1)	1	: (O) # Output Hts	8
: (A) Antennas (0 = beam)	15	**: (D) Disk (0AMDFPCBR)**	**F**
: (N) FFT size (power of 2)	7	: (B) Bottom_Ht to Output	180
: (R) Rate (50, 100 or 200)	200	: (T) Top_Ht to Output	540
: (E) First height (km)	90		

Disk = F: Frequency will be set by sounder, according to latest ARTIST scaling results (no later than 15 minutes old).

Sched(ule)

444. Pressing the ENTER key while "**Sched**" is highlighted will select the schedule editing screen as shown in Figure 4-14. Pressing the ESC key will exit the schedule editing screen, store the edited values and return to command menu selections at the top of the screen.

Schedule 1

Ø		15		3Ø		45	Á
1	D1	16	D2	31	D2	46	
2		17		32		47	D4
3		18		33		48	
4	BØ	19	BØ	34	AØ	49	AØ
5		2Ø		35		5Ø	
6	D2	21	D2	36		51	
7		22		37	D4	52	D4
8		23		38		53	
9	BØ	24	BØ	39	AØ	54	
1Ø		25		4Ø		55	
11	D2	26	D2	41		56	
12		27		42	D4	57	
13		28		43		58	
14	BØ	29	BØ	44	AØ	59	BØ

Figure 4-14 Schedule Editing Screen (Example)

445. The schedule allows the user to define the time (to 10 seconds precision) at which the programs are initiated, that is, a particular program may be assigned to commence at any minute of the hour plus 0, 10, 20, 30,

40 or 50 seconds. The screen reflects this by placing the program letter, followed by the tens of seconds digit, next to the minute that it will be initiated. If a program requires more than one minute, a vertical bar will automatically occupy the entire run time on the display screen.

446. A special scheduling feature is available by enabling either a D or an F DISK_IO (D) data format in Program G. This will cause the G program to commence automatically after ionogram programs in MMM, SBF or RSF data formats (i.e., D = M, B, S or R). This allows optimum use of time for alternating ionogram and drift measurements. To disable automatic drift execution after an ionogram, enter D = Ø in the G program.

Cntl (Control)

447. Pressing the ENTER key while “Cntl” is highlighted will select the control editing screen as shown in Figure 4-16 on the following page. Pressing the ESC key without entering any input value will exit the control editing screen, store the edited values and return to command menu selections to the top of the screen.

```
►(A) Active_prog    :  A                 (K) Active_sched :  1
 (B) Sched 1 Start  :  10                (L) Sched 1 Start:  -1
 (C) Sched 2 Start  :  20                (M) Sched 2 Start:  -1
 (D) Sched 3 Start  :  -1                (N) Sched 3 Start:  10
 (E) Sched 4 Start  :  -1                (O) Sched 4 Start:  20
 (F) Sched 5 Start  :  -1                (P) Sched 5 Start:  -1
 (G) Sched 6 Start  :  -1                (Q) Sched 6 Start:  -1
 (H) normal date 1  :  -1                (R) world date 1 :  -1
 (I) normal date 2  :  -1                (S) world date 2 :  -1
 (J) normal date 3  :  -1                (T) world date 3 :  -1

Item      Parameter      Abbrev    Range of Value     [Default Value]
 0       Active Prog      (A)         A to G

Entering the program letter will designate it as the ActiveProgram, to
be executed at the next user-initiated RUN command; NOTE that the
Active-Schedule has priority over the user-selected ActiveProgram
```

Figure 4-15 Control Editing Screen (Example)

448. The Control Editing Screen allows the user to manually set the currently active program and schedule. The currently active program is the one which will be executed if the Run command is selected; and the currently active schedule is the one which can now initiate preprogrammed measurements. This screen also allows the entry of times to switch from one schedule to another. For instance, by entering a 9 at **Sched 1 Start**, the active schedule will change to Schedule 1 at 0900 UTC every day. Up to six switches of active schedules can occur each day to allow different programs to be run during the night, day or transition periods. Note that there are three distinct levels of control here: hourly schedules, changes of hourly schedules during the day, and changes of daily schedules on specified dates.

449. In addition to switching programs and schedules on an hourly time frame, the entire sequence of events can be changed for certain "campaign" days, such as Geophysical World Days. For this feature, set up a **world date 1** (format is always four digits, month-month-day-day, such as 0930 for September 30) to go to the world day schedule start times which can be set in the right-hand column. The unique schedule start times allow selection of different schedules (1 to 6) specifying different programs (A to G) allowing the entry of different program parameters. The end of the campaign is specified by a **Normal Date** returning to the normal day schedule start times (the left-hand column) which take effect at 0000 hrs on the day specified. A "–1" in any schedule start times, normal dates and world dates will disable that parameter.

Run

450. As the measurement program progresses, the raw data is displayed on the monitor in the Data Display Window. As before, the Command Menu and Control Window will be displayed at the top of screen. In addition to that, two new areas, the Current Activity Window and the Color Code Legend, will be shown at the bottom of the screen. These are described as follows:

Data Display Window – The received echo data is plotted as a function of altitude for each frequency step at which a measurement takes place. There are always 128 discrete heights displayed. If 256 height samples (M = 256) are taken, every other one is omitted. The "spots" displayed as optifont characters.

Each increment represents 1.5 dB steps. Also in ionogram measurement mode, at a height of 600 km there may be additional rows of numbers. The first two indicate 1.5 dB overflows to be added to all values shown at that frequency step: the first applies to O echoes; the second to X echoes. This provides 48 dB of dynamic range across the display while at each frequency step, the data will have a 24 dB dynamic range for 1.5 dB pixel amplitudes. The overflow character DOES NOT reflect gain variations. The automatic receiver gain offsets are displayed as the fourth number at 600 km (the third is the most probable amplitude which indicates the noise floor or background noise). The gain offset is in units of 3 dB incremented by 2, 4, 6 or 8 (hardware attenuation is in 6 dB increments) for each attenuation increment applied. The colors displayed are described in the Color Code Legend section below.

Current Activity Window – In the lower left corner of the screen are a few dynamic indicators that are updated with each pass of the main program loop (about 20 times/sec). The DSP counter indicates that the program is waiting for the DSP to complete the Doppler processing of data from the current CIT. The current frequency is the last one displayed, not the one being acquired. Last is the disk record output counter which shows the file to which each CIT's output is being written. The H1 and H2 parameters show the height of the maximum echo at the current frequency (if more than one frequency are integrated simultaneously H2 shows the height of the maximum echo at the second frequency).

Color Code Legend – In the lower right corner are shown 16 numbered color squares. The even numbers (cool shades of blue and green) represent X polarization echoes while odd numbers (the hot colors) represent O polarized echoes. The first four colors of each group indicate a negative Doppler shift while the next four represent 0 Hz and 3 positive Doppler lines. For very long integrations made possible by multiplexing, Doppler shifts could easily exceed ±4 Doppler lines. These would be represented by the one of the four extreme positive or extreme negative colors describing the sense of the correct Doppler shift and the correct polarization.

The optifont character intensity represents 16 steps of 1.5 dB or 3 dB each, while Tables 4-2 and 4-3 define the color code used in the data display.

Table 4-2 Color Code Definitions for Vertical Incidence Displays

4-BIT BINARY	X	DOPPLER LINE #	4-BIT BINARY	O	DOPPLER LINE #
0	Dk Blue	Oblique**	1	Brown	–4
2	Blue	–3*	3	Brown	–3*
4	Green	–2	5	Dk. Red	–2
6	Lt. Green	–1	7	Magenta	–1
8	Lt. Cyan	0	9	Lt. Magenta	0
10	Cyan	+1	11	Lt. Red	+1
12	Lt. Grey	+2	13	Yellow	+2
14	Dk. Grey	+3*	15	White	+3*

* Since echoes which exceed the –4 to +3 Doppler line range are represented by these colors, their actual range of Doppler line # is –3 to –N/2 or +3 to +(N/2-1).

** Sources determined to arrive at a zenith angle greater than that set in ARMENU.DPS are tagged oblique.

NOTE

The screen display during drift operation uses all numbers 0 to 15 to show Doppler shift (–8 to +7) since normally no X data is taken.

Table 4-3 Directional (Beamforming) Ionogram Color Codes

X-POLARIZATION		O-POLARIZATION	
–X	Cyan	–O	Magenta
+X	Lt. Cyan	+O	Lt. Magenta
		–Oblique	Dk. Grey
		+Oblique	Lt. Grey

Utility Feature

451. Pressing the ENTER key while “**Util**” is highlighted will select the utility screen shown in Figure 4-16 on the following page. Pressing the ESC key will exit the utility feature and return to command menu selections at the top of the screen.

452. The Utility feature allows the user to select the following options.

a. View ionogram sequences using the VIEWER program*.

b. View drift data using SHOWDFT program*.

c. View individual ionograms using DISPMMM program*.

d. Edit the system settings file (ARMENU.DPS) as described in Section 6, AnnexA of this manual.

e. Run the BIT program.

f. Shell to DOS.

* Now better accomplished in newer systems by clicking on the desired file in Windows Explorer

453. If a PM is scheduled while the user is in the Utility mode, this and all other scheduled PM will be skipped until the user exits back to the Command Menu.

454. See Section 6 of the manual for a comprehensive description of the utility functions.

```
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 A     Ionogram History (RAM disk)  [ESC to quit]
 B     Ionogram History (HD):  [ESC to quit]
 B     ShowDFT (RAM disk)
 D     ShowDFT (HD)
 E     DispMMM (RAM)
 F     DispMMM (HD)
 K     Edit Station Characteristic File (ARMENU.DPS)
 L     Shell to DOS. Type EXIT to return to DPSCNTL.
 M     Run BIT test
 Hit   ESCape to return to DPSCNTL
```

Figure 4-16 Representative Utility Screen Display

Exit

454. Selection of this option will initiate an orderly shutdown of the sounder control software and exit to the DOS operating system.

455. Type RESTART to load and run the control program again.

CHAPTER 3

OPERATING INSTRUCTIONS
REMOTE COMMANDING

INTRODUCTION

428. The sounder operates FTP and WWW servers that allow remote computer platforms to connect for data visualization, commanding of measurement and housekeeping operations, software updates, and system troubleshooting. Figure 4-17 shows the sounder's web homepage with access to the remotely available operations.

Figure 4-17 Digisonde homepage

402. The sounder homepage provides several public access "latest data" displays that automatically refresh remote screens with new data. There are also several public interactive search-and-browse pages that allow access to the short-term archive at the sounder that holds recently made data (up to one month or more). A long-term archive of ionogram-derived (scaled) data is available that stores years of data in SAO format, with access to the source files and an interactive Java applet for their visualization as time series.

403. Password-protected system control pages can be used to modify measurement programs, schedules, and schedule start times. The latest system hardware status and dispatcher screen capture log can be displayed to the authorized users. The remote commanding services can also be used at the AUX computer console for

editing of the programs or schedules while the real-time console cannot be used because of an ongoing measurement.

404. FTP server allows access to the contents of D: drive of the AUX computer for a variety of software upgrades, commanding, and troubleshooting services.

REMOTE COMMANDING USING WWW SERVER PAGES

405. Figure 4-18 shows the remote control page with access to the same editing features as the real-time console provides, (1) measurement program editor, (2) schedule editor, and (3) schedule start time editor.

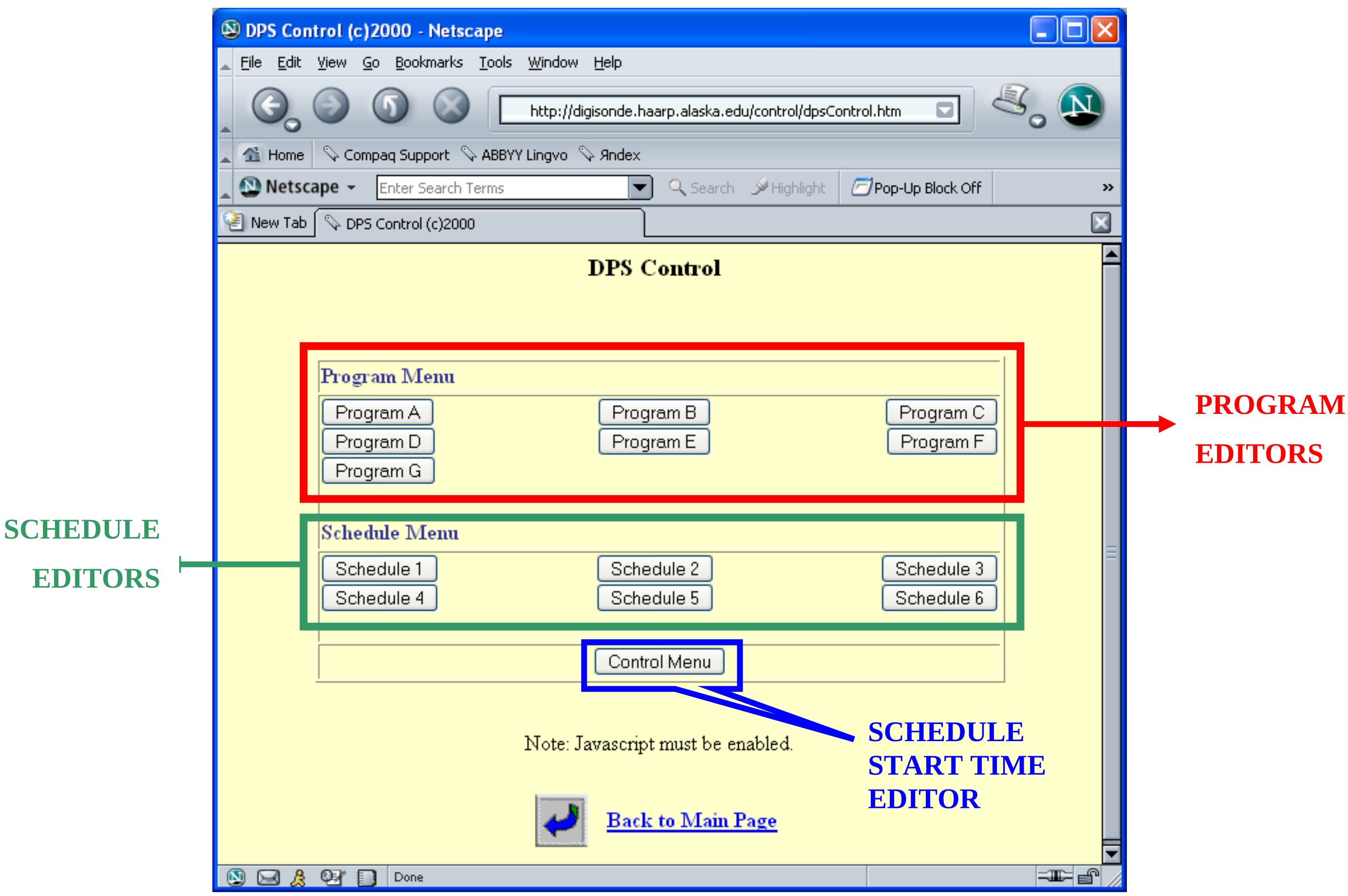

Figure 4-18 Digisonde control page with buttons starting program, schedule, and schedule start time editors

405. Remote commanding over the Internet allows modifications to the automatically scheduled operations of the sounder and does not support the real-time console functions that are used for manual commanding, e.g., manual start or stop of a particular program.

406. Figure 4-19, 4-20, and 4-21 shows a sample program in the editor page, sample schedule in the schedule editor, and sample schedule start times in the control editor, similar to editors provided by the real-time console (see Chapter 2 of this Section).

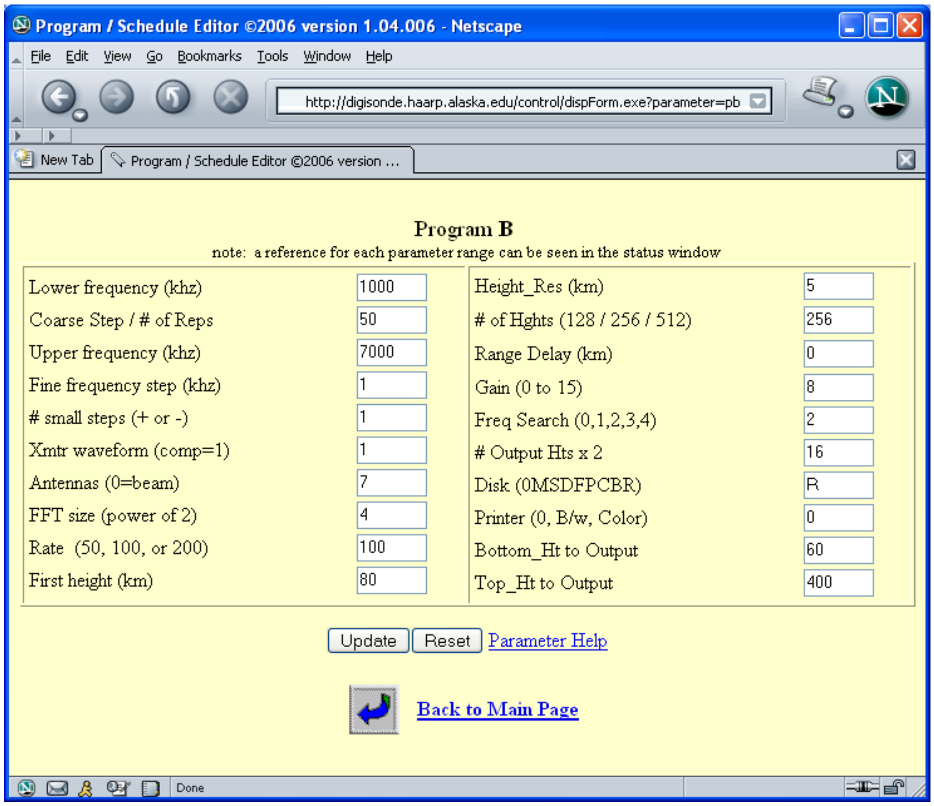

Figure 4-19: Program Editor

NOTE

When editing is completed in any of the editor pages, the Update button needs to be pushed in order to make changes effective. At this point the web script prepares a new PROGSCHD.DAT file and places it in the MAIN computer incoming folder for the DPSCntl to pick up and update its old definitions. If DPSCntl is busy with ongoing measurement, the changes will be pending the end of the measurement. Until that time, the web server displays information page instructing the operator to wait until DPSCntl can accept new PROGSCHD configuration. Thus, ONE CHANGE TO THE SOUNDER OPERATIONS CAN BE COMMANDED FROM THE REMOTE TERMINALS AT A TIME, unless the sounder is idling and is available for processing remote PROGSCHD update immediately.

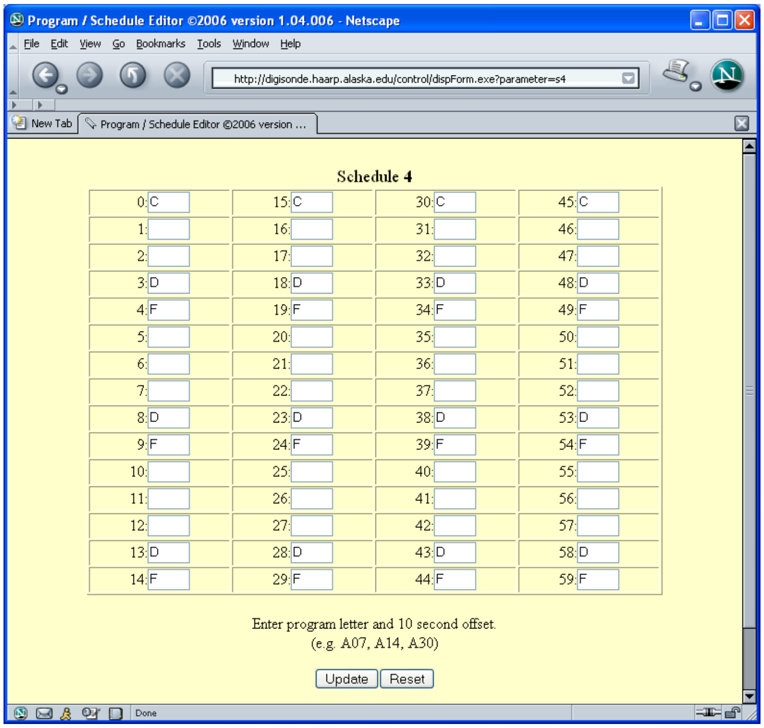

Figure 4-20: Schedule Editor

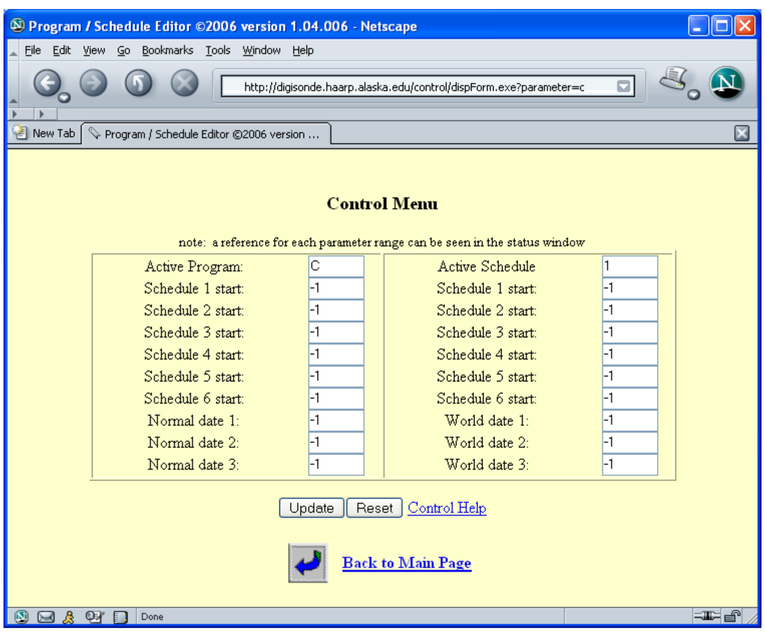

Figure 4-21: Schedule Start Time Editor ("Control Menu")

407. Similarly, it is possible to edit ARMENU configuration file and deliver new ARMENU.DPS to DPSCntl to update its settings. Figure 4-20 shows sample ARMENU editor screen. In order to update a value in ARMENU.DPS, the item to be changed needs to be selected in the “question” pull-down menu, and the new setting shall be typed in the “new value” form. Do not supply the question number in the new value form.

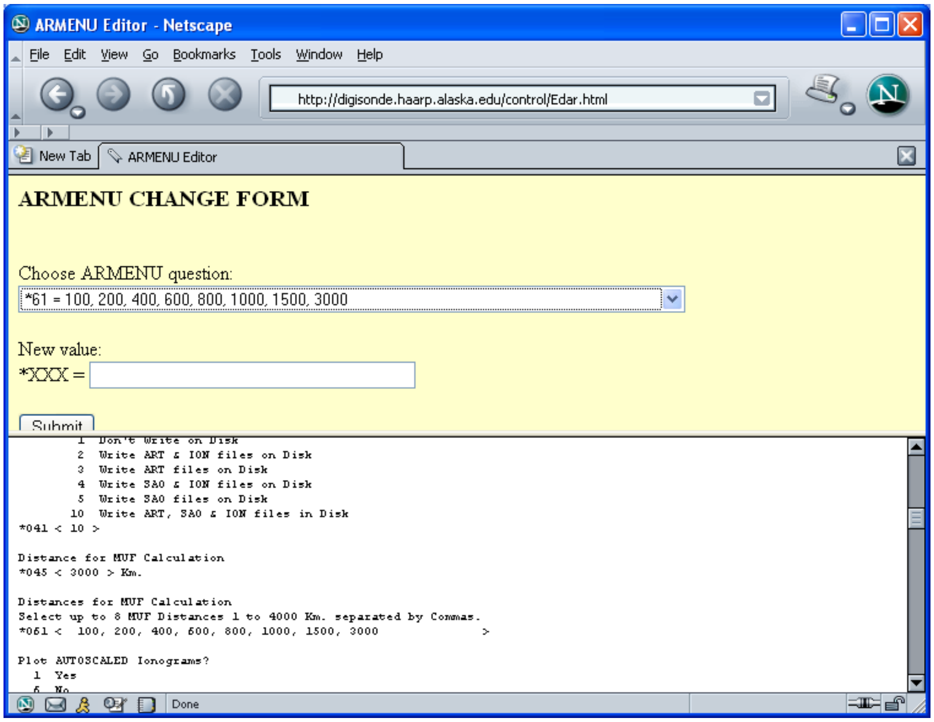

Figure 4-20: ARMENU Editor

REMOTE COMMANDING USING FTP SERVER

407. Using the FTP server, it is possible to download existing PROGSCHD definitions, edit them on a remote platform and upload back. This way it is possible to introduce multiple changes to the definitions without waiting for the MAIN computer response to each change. The PROGSCHD.DAT file is located in D:\DPSMAIN\DPSOPER folder. Once the file is edited, it should be placed in the D:\DPSMAIN\AUX2DPS\ folder and then renamed to PROGSCHD.REM. Direct updates to the PROGSCHD.DAT file in the D:\DPSMAIN\DPSOPER folder are not detected by DPSCntl and will not become effective until MAIN computer reboot. Direct upload of the PROGSCHD definitions as PROGSCHD.REM file to D:\DPSMAIN\AUX2DPS\ folder may cause premature read operation on the file by DPSCntl while the FTP transfer is still in progress.

408. Similarly, ARMENU.DPS file can be downloaded, edited and placed in \AUX2DPS folder as .REM file.

409. It is possible to command restart and abort to DPSCntl over the FTP by placing MESSAGE.REM file to D:\DPSMAIN\AUX2DPS folder. MESSAGE.REM file is a one-line text file with the following options:

<RESET>

reboot MAIN computer after the end of measurement

<REBOOT_NOW>

reboot MAIN computer immediately

<MAINTAINANCE>

start maintenance cycle (see further description in Section 7)