MANUAL FOR THE A.U. DIGION SYSTEM.

Version 3.1 J. E. Titheridge, March 1994.

(Software Updates since 1994 are described in the 'Readme' file on the diskette).

1 INTRODUCTION

1.1 Purpose of the equipment

The Auckland University DIGION system is used to extract and store digital ionograms from an IPS-42 ionosonde, as supplied by KEL Aerospace Ltd. For this purpose the operation of the ionosonde is controlled by software running in a standard IBM-compatible microcomputer. Normal operation of the ionosonde is not affected — the collection of digital ionograms runs in parallel to any film programme. Thus you might collect ionograms on film at 30–min intervals, and store digital ionograms every 5 mins. Additional ionograms can be recorded at any time by pressing ENTER or by an external hardware signal. The most recent ionogram is always available in a file LAST.ION , for remote viewing. All stored data include headers giving the station number (0,1 = Auckland, 2= Christchurch..) and the date and time of collection, as well as the normal I.D. written on the 'uncleaned' hourly ionograms (section 3.3).

Control and data signals from inside the ionosonde are processed and buffered on a small interface board mounted inside the rear panel. The computer may be 10 metres or more from the ionosonde, and is connected to it by a special double-shielded cable. Synchronising and data signals received from the ionosonde are processed by a board fitted inside the computer. A timing signal is also used to correct the computer's clock every hour, to maintain agreement with the ionosonde. At programmed intervals the computer causes an ionogram to be collected and displayed on the monitor screen of the IPS-42. The ionogram data is also read by the computer, using a high-resolution mode (with steps of 1.6 km in height, and 0.5% in frequency). The data is compacted by a factor of about 10, using a modified run-length encoding, and stored in a separate file for each day. Ionograms can be recorded at a maximum rate of at least one per minute, with even the slowest computer. For a normal schedule of 5-minute ionograms, data for one day (288 ionograms) occupies about 1 MB of disk space. Thus a 40 MB disk can hold all programs plus data for a full month. This is extended to two months if the files are 'zipped' automatically every few days, as described in section 3.3.

At regular intervals (normally every five days) the software copies the data files to tape or other storage medium, with compaction by a further factor of about 1.8. Storage of 5–min ionograms for a full month typically occupies 15–20 MB, depending on the density of the records (e.g. the extent of spread echoes). A separate software package is supplied for replaying the data for examination and scaling (section 4); this is best carried out on a reasonably fast computer with a VGA screen.

Extensive noise-cancellation and interference suppression measures are included, in both hardware and software, to ensure reliable operation. All digital ionograms include everything visible on the film records (except when the ionograms are specifically 'cleaned'), with appreciably enhanced resolution. The main advantages of this equipment are (1) freedom from the hassles and cost associated with recording, processing and storing film ionograms; (2) the ability to record 5–min data with very little additional expense; (3) the ability to obtain ionograms from a remote site (by modem); (4) the convenience of scanning clear, high-contrast ionograms on your own P.C., and making immediate comparisons with data from the next (or previous) hour or day; (5) the ease and accuracy of scaling digital data, with an automated display of fo and fx at the correct spacing; and (6) the ease of making and sharing copies.

1.2 Parts supplied

You should receive the following items:

1. A small interface board, with a DB15 socket and colour-coded leads, which mounts inside the rear panel of the ionosonde, with additional "**Installation Instructions**" to supplement the material in this manual.
2. A double shielded cable, with DB15 plugs at each end.
3. A half-length printed-circuit board for insertion into a free slot in the computer. This has a DB15 socket for the connection to the ionosonde, and a miniature phone jack which can be used for an external control signal. (Version 3.0 hardware used a full-length wire-wrapped board in the computer.)
4. A floppy disk containing programs to (a) operate the ionosonde, and collect, compact and store the digital ionograms (DIGION.BAT and GETION.EXE); and (b) replay stored ionograms for display and analysis (DIGION.EXE) or for the extraction of time variations (VARION.EXE). There is also a program PORTADR.EXE for verifying the availability of port addresses (as 2.2.1). The public domain programs PKZIP and PKUNZIP are provided for further packing of data files, and a good text editor for modifying batch files (QED.EXE , with help files accessed by ESC or F1). A sample file 02JUN93.ZIP contains ionograms recorded on 2/6/93, in standard format (compacted and zipped, section 4.1).
5. A copy of this manual.

You must provide the IBM-compatible computer, with at least one free slot. The simplest, slowest machine will do, preferably with a hard disk for convenient storage of ionograms. For long–term storage we use 1/4" streaming tape cartridges. The ionogram collection program GETION is compiled using 8086 instructions only, so that it will run on any IBM-compatible machine. It assumes the presence of a monochrome graphics screen; Hercules is normal, but it will also recognise and use EGA/VGA. The display/analysis programs DIGION and VARION are normally compiled using 80386 instructions and assuming the presence of a maths co-processor. A VGA screen is also desirable, preferably colour, since this program is normally run on your office machine. Versions compiled for other configurations can be supplied, or compile your own using the source code provided.

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<u>NOTE</u> that the equipment as supplied will operate on your computer only if the I/O addresses 240 to 243 (hex) are free. Check these as in 2.2.1 below in case you need alternative software.

2 INSTALLATION

2.1 Modifying the IPS-42

This is the only difficult part. You will need screwdrivers, electric drill, file and soldering iron, plus a multimeter and an oscilloscope. You may need to refer to your circuit diagrams. The extension cable supplied with the IPS-42 is also required, to permit bench operation of the ionosonde control chassis (or we could lend you a suitable cable).

Detailed step-by-step instructions for modifying the IPS-42 are provided on four pages enclosed with the interface board (Z-493-11). This also gives a table of connections, with sketches of the expected signals, and a template for the panel cut-outs. The description below is given to incorporate a record of the connections, and a description of the signals, into this manual.

2.1.1 Mounting the output board

The small printed-circuit board, with a DB15 (15-pin) connector and several flying leads, is installed in the rear of the ionosonde. Before beginning this, disconnect the mains power supply and the battery backup from the ionosonde. Ensure that the transmitter unit is switched off (on the rear of the chassis).

First remove the top (control) section of the ionosonde (remove the front panel, front and back bolts, and the two heavy-duty plugs and R.F. connectors on the rear). Unscrew and release the larger rear panel of this unit, as far as the two RF cables allow, so that the panel can be placed flat on the workbench. Using the layout template provided in Appendix 5 (and in the installation instructions, cut a hole in the left hand side of the rear panel (as viewed from the rear of the ionosonde) to the size of the DB15 connector. Small slots must be made at the top and bottom of this cut-out so that the DB15 socket, without its shroud, can be passed edgewise through the panel. Drill holes to match the four corners of the interface board, as shown in Figures 1 and 2. These holes straddle the vertical U-section to which the rear of the control chassis fastens in the IPS-42.

Mount the board on the inside of the rear panel, using the bolts and standoff insulators provided. The ribbon cable comes from the top, passes down behind the board and reappears on the right hand side near the DB15 cutout. Pass the DB15 through its cutout and bolt it in place with the external shroud.

2.1.2 Connecting the output board

Within the ionosonde, outputs are taken from the edge connectors for Board 5 (Digital Section, seconds), Board 8 (Digital section, N.I. Generator), Board 17 (Program Board, switch section) and Board 18 (Power supply). Before starting, all boards should be carefully identified and labelled on the top supporting channel. If in any doubt remove a board to check the number marked on it.

Viewed from behind, the power supply board 18 is on the extreme left. Then there is a gap to board 17, which has a front sub-panel holding the rotary 'MONITOR' and 'MAIN' control switches and push-buttons. After a further gap come Boards 0 to 8 and 10 to 13; we have no board 9. Boards 1 to 3 have micro-switches for setting years, days and hours. Board 5 has one switch (reset secs), and Board 7 has 2 switches.

Make sure that the connectors for Boards 5 and 8 are correctly identified. The sockets have 33 pins numbered consecutively from the top, so when viewed from behind the odd numbers run down the left and the even numbers down the right of each socket.

A. MAKE ONE INTERNAL CONNECTION TO THE IONOSONDE. From the front of the control unit, remove the screws holding the main switch unit (Board 17, with the rotary main, monitor switches) and slide it out. Two wires come from the back of the 'MONITOR' pushbutton. One goes to a stand-off pin near the top of board 17, labelled S3. The other goes to a stand-off slightly lower down, which connects to pin 1 of IC8 (a 7400). The free end of the grey wire (supplied, with a single–pin connector on the other end) solders to this point. Reinsert Board 17.

B. CONNECT THE FOUR POWER LEADS coming from the end of the interface board (Table 1A, Appendix 5). The control unit should first be powered up on the bench to check the location of the required voltages. Double check that the transmitter unit is switched off, and connect the IPS-42 extender lead from SK1 (the connector near the added DB15) to the corresponding ionosonde plug (PL1). Switch on. 12 volt power appears at the wire-wrap pins 3 and 2 at the rear of the power-supply board (number 18, at the left when viewed from the rear of the ionosonde). 0, 5 volt lines are pins 1 and 17 of the bussed sockets 1 to 13.

Switch off. Connect the +12 V lead (red) to pin 3 of Board 18. Connect the -12 V lead (black) to pin 2 on Board 18.
On Board 2, connect the 0 V (green) lead to pin 1 and the +5 V (yellow) lead to pin 17.
These connections are listed in Table 1A (Appendix 5). Power on to check that the correct voltages appear at the interface board.

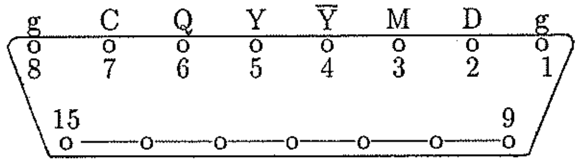
C. CONNECT THE SEVEN SIGNAL LEADS. Use an oscilloscope to locate the signals described below, on the IPS-42 edge connectors. Signals 1 and 2 appear continuously. To see the others you must initiate a sweep by pressing the MONITOR button (with the Monitor switch S1 set to 'Single'). The connections and signals, described below, are summarised in Table 1B (Appendix 5). When all signals have been identified, switch off the ionosonde and make the connections. Note that the push-on connectors are rectangular and should be oriented to match the socket pins. Mistakes here cannot damage the ionosonde, since all connections (apart from that soldered to one side of the'MONITOR REQUEST' pushbutton) simply take signals from the ionosonde and feed them to high impedance inputs.

1. Board 5, Pin 27 is the 96 kHz clock signal; this runs continuously. The red lead (from 'C' on the interface board) clips on here.
2. Board 5, Pin 10 is the 'MIN' pulse, which goes high from 0 to 20 sec of each minute. The brown lead ('M') clips on here.
3. Board 8, Pin 31 provides the XMR signal, which is normally low. It goes high for a period of 14 sec to define the time during a scan when the transmitter is active. The orange 'X' lead clips on here.
4. Board 8, Pin 3 is the YB blanking signal. This goes high for 5.3 ms every 21 ms, when the echo data is being shifted out to the oscilloscope screen. The white ('B') lead goes here.
5. Board 8, Pin 18 provides the video DATA output. This is normally low (but is high if the control unit is run with no receiver input). When the ionosonde is operating, it pulses high during a period of 5.3 ms every 21 ms, at times corresponding to a trace on the monitor screen (when YB is high). Connect the Blue ('D') lead here.
6. Board 17. The grey lead connected in A is used for a MonReQ line. This currently is at +5 volt, dropping to 0 V when the 'Monitor' button is used to request a sweep. Plug this in to the grey lead coming from 'Q' on the interface board.
7. Board 17, Pin 30 is the 'SCAN' signal. During each sounding this normally high signal goes low for a period of 18 sec, from 2 sec before XMR to 4 sec after XMR. The black lead from 'S' on the interface board goes here.

2.1.3 Checking the output board

Examine the signals on the DB15 socket (using a resistor wire clipped in your probe, to push into the socket). The bottom row (pins 9 to 15) and pins 1, 8 are linked and act as signal earth. Other pins are checked as follows, beginning with the simplest signals. A 'high' on these pins (connected to RS232 drivers) is about +12 volts, while 'low' is around -12 V. The expected signals are summarised in Table 2 of Appendix 5.

The DB-15 socket viewed from the rear of the ionosonde.



The C, Q, M and D signals are as described in section 2.1.2, except that they are inverted on the cable and sockets. Pins 1, 8, and 9-15 serve as signal ground. The outer case and shroud are connected to the outer R.F. shield on the cable.

Pin 3 (M) is the 1-minute timing line. This is the complement of the MIN connection made above, since all cable signals are inverted by the RS232 drivers. Thus M should be low from 0 to 20 sec of every minute, and high from 20 to 60 sec. If incorrect, check the MIN input signal (brown).

Pin 7 (C) has the clock signal, a 96 kHz square wave which should appear at all times. If it is not present, trace it back to the ionosonde on the red lead.

Pin 5 (Y) is a control output which is normally low, at this point. Push the monitor request button to initiate an ionogram. After the normal wait (of up to 20 sec) this Y signal goes high for 2 secs. It then pulses low for 5.3 msec at intervals of 21 msec. There are 576 pulses, one for each of the transmitted frequencies, before the ionogram is complete and the Y signal returns to a steady low level.
If Y does not go high, check the XMR and SCAN lines above (the orange and black leads).
If Y goes high but does not pulse, check the YB input line (white).

Pin 4 ($\overline{Y}$) is the complement of the Y signal, used for noise cancellation logic.

Pin 2 (D) is the ionogram data (the complement of the DATA signal described above). If incorrect, ensure that the (inverted) signal appears correctly on the blue input lead.

Pin 6 (Q) is the reQuest line, driven by the computer to initiate an ionogram. It is normally low. To check this connection short pin 6 to pin 4 (the normally high $\overline{Y}$ output) for about 1 sec. This pulls the reQuest input high (so the reQuest line above goes low) and should initiate a sweep on the monitor scope.

If the input signals are all correct but any output is not, return the board to us for testing. Note, however, that all equipment (boards and cable) have been tested and run without problems, so please double check the signal inputs and supply voltages before calling for help.

2.1.4 The connecting cable

This cable may be up to 10 m long, using an overall R.F. shield separate from the normal signal ground. It has two DB15 connectors and should be connected as labelled since the internal shield is wired differently at each end. Within the cable the lines Y, $\overline{Y}$ are paired. Other pairs are 2, 1 and 7, 8 so that the data and clock signals have an accompanying earth. The fourth pair carries the low-speed signals M, R. You could at this stage check for correct signals at the far end of the cable, although errors here seem unlikely.

2.2 Setting up the Computer

Any IBM-compatible computer can be used to control the ionosonde, since we use only the 8-bit data bus. You will probably want one with a hard disk (an XT or later). For 5–min ionograms you need about 1 MB of hard disk space per day. 40 MB will comfortably store 5–minute ionograms for over one month (9,000 ionograms) before you need to copy them to some other medium. Storage requirements can be further reduced by a factor of about 1.8 by compressing the files (with PKZIP) as in section 3.3 below.

2.2.1 Hardware installation

The control and signal processing electronics are provided on a half–length board designed to fit into any spare slot in the P.C. This board uses only the 8-bit data bus so it will work with any machine – 8088, 80286(XT), 386, 486,.. The computer must have a real-time clock which will keep the date and time reasonably correct (within 30 sec) during any power failures.

The interface board as provided uses the I/O addresses 240 to 243 (hexadecimal). These have been chosen as normally unused by other equipment, but their availability should be checked. To do this, load the program PORTADR.EXE from the supplied disk, and run it. Enter '240' in response to the prompt for an address. If this address and the three following ones seem free the computer will say so; otherwise try other addresses from the list below until a free area is found.

Available addresses run from 200 (hex) to 3E0. They are set by the DIP switches on the interface board, which should read 0010 (from left to right) at present. The control lines are pulled high, so that '1' is off (down) and '0' is on (up). Switch settings for other base addresses are shown below:
200=0000, 220=0001, 240=0010, 260=0011, 280=0100, 2A0=0101, 2C0=0110, 2E0=0111
300=1000, 320=1001, 340=1010, 360=1011, 380=1100, 3A0=1101, 3C0=1110, 3E0=1111

If some address other than 240 must be used, the program GETION will have to be fully recompiled including all the C++ and assembler routines. This will normally be done in Auckland.

When the I/O addresses are verified, switch off the computer and open the case. Locate a spare slot and plug in the supplied board.

2.2.2 Software installation

Software is provided on a 3.5" (1.44 MB) disk, since this is more reliable for mailing. The disk contains programs for data analysis, as described in section 4.1 below, and for data collection. Source listings are provided for the higher level programs (written in C++) which determine when ionograms are collected, how they are stored, and how they are later displayed; this allows you to adjust operations to suit yourself. You may need to copy GETION.EXE and DIGION.BAT to a 360 kB floppy for transfer to an older data-collection computer. Copy DIGION.EXE as well if you may wish to check the collected data on site (but note that DIGION , as supplied, requires a 386/486 processor). Operation of DIGION can be seen using the file APR93.20 (as in section 4.1).

It is assumed that the running program and the data files produced will reside in the same directory. So first make an appropriate directory (e.g. C:\IONO) and copy the files GETION.EXE and DIGION.BAT from the supplied disk. The compiled program GETION.EXE is ready to run. Note that in the dialogue below, waiting for more than 20 secs to any question gives a default (positive) answer so that the program continues without intervention.

Running GETION without installing the interface board should first produce a message

Computer Date= 10-05-93; Time= 17:44:57.

Are these within +/-30s of the ionosonde time [Y or N]?

Entering anything other than 'Y' (or 'y') exits the program for you to correct the computer clock. 'Y' leads to the message

Enter the desired time interval between soundings ?

[1, 2, 3, 5,...,60 minutes. Default = 5 mins] 97

Run in Debug mode. Will use data file MAY93.10

Entering reset: Ports are initialised.

Computer Date= 10-05-93; Time= 17:46:28.

Waiting to sync with ionosonde: MIN high; WAITing to go low....[kbd–>cont]

In the example above (copied from my screen on 10/5/93) I have entered '97' as the required time interval between soundings. Any value over 90 is recognised as a dummy for program testing without an ionosonde. The program then provides simulated signals (on every n'th sounding frequency, when the time interval is 9n). Also, whenever a message says WAITing with the WAIT in capitals, pressing 'Enter' will simulate the required signal. The above messages show that the program is now waiting for the ionosonde MIN pulse (at 0 or 20 sec past the minute) to accurately synchronise the computer. Simulate this by pushing Enter gives:

Data file MAY93.10 is empty but in use.

Times from INITIALISE(), as set in SYNC():

Date= 10-05-93. Time= 17:47:20.

Leaving INITIALISE().

CONTROL() at 17:48. WAIT to next Sweep-Time(*97 min) [or kbd]...

The last line above says that the program is in the CONTROL routine, waiting until it is required to collect an ionogram. This will happen at the next programmed time (the next multiple of 97 minutes, in this case). Or a sweep can be initiated at any time by pressing ENTER , on the computer, or by a remote signal using the phone jack on the interface card. Pressing ENTER now will produce

Keyboard Sweep Request: Now.

In GETSCAN(); –> VIDSCAN.

VIDSCAN() freqs 1 to 577, height= 64 bytes.

–>WAITSOUND():Trigger Sweep. WAIT for Y –>Low (at 0,20,40s)...[kbd–>cont]

ENTER again to simulate the Y signal from the ionosonde, gives

–>SOUND in 2 secs... MODEL DATA at F= 1 8 15 22 ... 561 568 575 : Freqs 1 to 577 recorded.

Leaving VIDSCAN(). Re-synchronise Clocks in Getscan: MIN high; WAITing to go low....[kbd–>cont]

The "Re-synchronise Clocks" occurs only after the first ionogram collected in each hour, to ensure that the computer's time keeps accurately in step with the ionosonde. Press ENTER and you will get

Saving data; Then display.

COMPACT 36928 to 5xxx.

followed (after a 3 sec wait) by a display of the recorded dummy data. This has a dotted frame and tick marks added by GETION . The last line above shows that the raw data occupies 36928 bytes, which is reduced by the compaction algorithm to about 5600 bytes (for the dummy data). When a "cleaned" ionogram is recorded, with a frquency range limited to 1.3–16 MHz (section 3.3), the size of the raw ionogram will be 29760 bytes. Above the screen display the computer shows that it is back waiting in the CONTROL section of the program.

Several ionograms can be recorded by repeatedly pressing ENTER . The first ionogram in any hour shows all collected data. Following ionograms will show the areas which have been blanked out during the data 'cleaning' process (section 3.3) to reduce the size of the stored ionogram. Press ESC to exit the program. Running DIGION on the data file produced (MAY93.10 in my example, or use DIGION LAST.ION to see only the last ionogram) will redisplay the recorded ionograms as in 4.1 below.

2.3 Ionosonde operation

Connect the cable from the ionosonde to the computer. Internal shielding is connected differently at the two ends, so ensure that the cable is the right way round, as labelled. Trigger an ionogram, using the MONITOR button on the IPS-42, and check that the computer doesn't bomb. Ours never does with the new cable. If you do have trouble try different cable routings, keeping it down near the ground as far as possible, different positions for the ferrite clamps, and different mains sockets for the computer. It could be necessary to earth the outermost shield at a few places, to reduce the R.F. interference — we had to do this before we went to double shielded cable. Additional ferrites (provided) can be tried at different positions on the cable. A fuller check on the level of interference can be carried out with the program GETALL.EXE , as in section 2.4.

Type TIME to check that the computer's time agrees with the ionosonde (which is taken as the local standard) to within 30 secs. Note that computer date and time must be set to UT if that is what your ionosonde uses. Run GETION and answer 'Y' to the first question (or wait 20 secs, when the computer will assume a 'Y' answer). The program will then adjust the computer's clock at the next transition of the ionosonde 'MIN' signal (at 0 or 20 sec past the minute), and ask for the required time interval between ionograms. Again you may enter a time, or just wait and after 20 secs the program will assume the default value of 5 minutes. This timed response is used so that everything can restart and run without operator intervention after power failures or other interruptions. Entering a negative time interval has the same effect as a positive value, except that it reduces the amount of information listed on the screen.

Screen output is basically the same as shown in 2.2.2 above. After the time interval is set, the program seeks for today's data file. If it exists the computer lists a summary of the contents; if not it creates the file mmmyy.dd and notes, for example, "Will use data file FEB93.23" . It then waits in CONTROL , as in 2.2.2 above, for the next time it should record an ionogram. At this stage you can initiate a sweep immediately by pressing ENTER . You can exit the collection program cleanly at any time by pressing ESC .

On pressing ENTER the program activates the MONITOR SWEEP input on the IPS-42, which should cause the top Monitor light to come on. It then waits for up to 20 sec for the ionosonde, which will sweep only at 0, 20 or 40 sec past each minute. When the sweep time arrives the screen displays Sound in 2 secs... . During the sweep the computer is busy collecting data, and shows nothing. After the complete ionogram is obtained the computer may resynchronise its clock with the ionosonde; this occurs on the first ionogram collected in each hour.

After collection the ionogram is compacted, and the computer displays a line such as COMPACT 36928 to 3xxx bytes , waits for 3 secs, and displays the ionogram. Ionograms nearest the hour (from a routine recording program) are retained in full, giving a compacted size of about 7 kilobytes (kB) per ionogram. All other data is first 'cleaned', as described in 3.3 below, reducing the average size to about 3.5 kB; this can vary from about 2.5 to 4.5 kB depending on the density of spread echo or noise traces. To increase (or decrease) the number of uncleaned ionograms, for test purposes etc, call GETION with three arguments as described in section 3.3.

After compaction the ionogram is saved in the current daily file, and then plotted on the screen. The number of pixels which can be shown vertically is limited by the screen, to 348 for the common

Hercules video. So to show the 512 echoes at heights up to 800 km the program has to omit some data. This is done by determining the screen resolution, and regularly omitting every n'th data point (where n = 3 for a Hercules display, leaving 341 displayed pixels, and n = 8 for a VGA screen). The last ionogram is displayed continuously while the program waits for the next time at which an ionogram is required, as shown by the message from 'CONTROL' displayed at the top of the screen.

Horizontal graticule and tick marks are two pixels high, when recorded with the doubled (1.6 km) resolution, although the displayed width may be reduced to one by the limited screen resolution. The 512 pixels collected vertically include one pixel from each of the bottom and top graticules. No attempt is made to collect the second top pixel, since it arrives just as transmission begins on the next frequency. The full frame and tick marks are recalculated within GETION and shown as dotted lines on the display, to provide a reference for 'cleaned' ionograms. For full ionograms the dotted lines and the recorded frame should coincide.

The latest ionogram is also always available in a separate file LAST.ION so that it can be retrieved by communications software for remote viewing. This file is in the standard format so that the ionogram can be viewed by the statement DIGION LAST.ION as in 4.1 below.

2.4 Error messages

After each data collection sequence, but before the ionogram is displayed, any errors noted by the software are shown (heralded by a beep, and followed by a 4–sec wait for you to read them). These errors can relate to a failure of the Y signal to be in the expected high state initially, or later to go low, or to pulse high in each of the sounding frequencies. Similar failures of the DataRdy signal (derived from the Clock and Y inputs) are also noted, using the error numbers listed in Appendix 2. Error EISDEAD (=10, amplified by a listed value of ernum= 11 to 15) occurs during the assembler program SOUNDS , while errors 20 to 24 are from the higher-level C program SCAN. These errors do not now occur in practice, unless there is an open connection from the computer to the ionosonde – and you will have been warned of this already when the computer stops at MIN low/high; WAITing to go high/low....[kbd–>cont] . One exception is error 23 (Y already high) which indicates that the ionosonde was already sounding when GETION requested a scan. This can occur through conflict with a film recording program, or with a scan initiated manually on the IPS-42.

An error message which may occur during data collection is, e.g. Data-Ready Errors = -4.
This shows that, in collecting the 36928 bytes of data (64 at each frequency), there were 4 occasions on which the data byte did not appear exactly on schedule. This always (?) corresponds to the last data byte at a given frequency, which is being read just as the transmitter begins its first pulse at the next frequency. This is also the time at which the top graticule is being displayed on the CRT's (which is why we don't attempt to collect the second pixel of this graticule). R.F. resonances, mostly at frequencies above 10 MHz, interfere with the ionosonde to cause a downwards displacement of short sections of the top graticule – this can be seen on IPS-42 ionograms from most stations (Appendix 3(a)). The same resonances can occasionally affect collection of the top data byte. When there is any abnormality at any frequency, that frequency is marked by setting the top byte to FF (hex). And the number of "DataReady" signals, which are all counted, will be one too low.

The message Data-Ready Errors = -4 indicates that this problem occurred on four frequencies. The recorded ionogram will show four short bars extending down from 800 to 788 km – blanking out the region where data was doubtful. The number of error-bars will vary depending on your local arrangement of computer, wiring and shielding. For the IPS-42 alone the hooks on the top graticule are minimised by installing all screws on the front and back panels. Interference at the computer also depends on the power point earthing, the position and earthing of the connecting cable, the position of the ferrites (which can be unclipped and moved), and on whether you jumper the outer cable shield to the computer case. The number of DataReady errors is listed so that you can readily adjust things to minimise interference. Our number started off at about 20, without the ferrites. With Version 2 we got only three doubtful bytes from the 36,928 collected, while with Version 3 of DIGION we get none.

To help minimise the level of interference with Version 3, the program GETALL.EXE is provided. This is the same as GETION.EXE except that the hardware is not disabled (by the computer) while the transmitter is firing. Thus it may show some error messages, and the number of these should be minimised as described above. Note, however, that these "errors" have no ongoing effect in normal recording. Expected signals are double checked at all times, and data collection is completely re-synchronised at each new frequency. Any lost data (an occasional lost top byte, at worst) is much less than that due to the hooks which occur in a similar position on all our film ionograms (as in Appendix 3(a)).

3 ROUTINE OPERATION

3.1 Setting the recording programme

It will be assumed that you are running GETION , and collecting ionogram data files, in a directory C:\IONO. Copy the files GETION.EXE and DIGION.BAT from the supplied disk into this directory. The batch file DIGION.BAT oversees the routine operation of the ionosonde, and storage of the resulting files. To ensure that it is called whenever the computer reboots, add the following two lines at the end of your AUTOEXEC.BAT file:

```
C:\IONO
DIGION
```

These serve to restart DIGION so that data collection carries on normally after power failures or other problems. The file DIGION.BAT as used at Auckland is listed below:

```
rem DIGION.BAT used at Ardmore.   Esc, or >10 resets in 1 day, -> 0 -> end.
rem New day -> 1 (for a new file);   5th day -> 2 to save data.
set sitenum = 1          [<<- Change '1' to your desired Site Number]
:begin
getion 5 0
if errorlevel 2 goto save
if errorlevel 1 goto begin
if errorlevel 0 goto end
:save
cd \tape
tape backup c:\iono\???9?.* /j/k/-s
cd \iono
if errorlevel 1 goto begin
del ???9?.*
goto begin
:end
```

At start-up, this file first sets the environment variable SITENUM , which provides the site identification number to be stored with each ionogram. This is new to version 3.1. It removes the need for the GETION program to be recompiled for each site, so that a unique site identifier can be stored with all ionograms. If SITENUM is not set in this way, the number built in to the program (possibly 1, or 99) will be used for the site identifier.

DIGION.BAT then calls the GETION program, to synchronise the clocks and collect ionograms at 5-minute intervals. As shown the GETION command takes two optional arguments. The first specifies the value 'time-interval' at which ionograms are to be collected. Inserting it here bypasses the request (and subsequent 20 sec wait) for an interval to be entered manually. The second argument specifies a time-offset, if ionograms are not to be collected on the hour. Thus a line GETION 10 2 would cause ionograms to be collected at 2, 12, 22, .. 52 minutes past the hour; this is sometimes required to avoid the period of 0 to 2 mins past the hour when a special watch is kept for distress signals. A third argument can be added to specify which ionograms should retain the full graticule and date-time information (section 3.3).

The program GETION runs continuously for 5 days, under normal conditions. It returns control to the batch file only when (a) the program is interrupted by pressing ESC (giving an exit with errorlevel = 0); (b) the day changes, or persistent errors in the received signals force a system reset (giving errorlevel = 1); or (c) there is a change of day and the new day number is 1, 6, 11, 16, 21 or 26 (this produces errorlevel= 2). More than 10 resets on any one day lead to an abort (errorlevel 0) requiring operator action.

Case (a) returns control to the user. Restart the system by entering DIGION or by rebooting the computer. Case (b) automatically restarts the data collection. After any such restart, new ionograms will be stored in a new file if the day number has changed. Case (c) is used to reduce disk storage, by appropriately disposing of the data files obtained in the last 5 days, as discussed below (section 3.3). With slow computers copying 5 MB of data to tape can take more than 5 mins, so that one ionogram is missed every fifth day. To just compress the files, replace the three lines following :save by PKZIP %_date ???9?.* , as described in 3.3.

Note that a file logfile.log is maintained by GETION at all times. This records the dates and exact times of all initialisations, resets, disk errors and other possibly relevant information. The file retains all such messages, growing continually (but very slowly – at 2 lines per day in the absence of errors) until it is deleted. A new file will then be opened on the next run.

3.2 Other recording procedures

For intermittent operation, or for remote collection of ionograms on demand, there are three possibilities.

(1) When in the program GETION , an ionogram can be obtained at any time by a control signal inserted at the 3.5mm stereo phone jack mounted on the rear of the computer board. A two-wire, shielded cable is required. The lead connected to the jack tip is the signal, and the ring connection is signal earth. These must be kept separate from the outer shield (which is needed to prevent problems caused by RF pulses from the ionosonde). The 'signal' input is normally high. To request an ionogram, pull this low by a TTL control signal, or by shorting it to the signal earth line. The computer then displays the message
External Sweep Request: Now. and will proceed to take and store an ionogram. This is added to the current daily file, and is also stored in a separate file LAST.ION for immediate transmission.

(2) If GETION is invoked by a command line GETION filename then the program GETION.EXE is begun, one ionogram is recorded and copied into the file "filename", and GETION exits. A batch file can therefore be used to obtain a single ionogram when requested, and then to

transmit this to some other site.

(3) In all recording programmes the most recently recorded ionogram is always available in the file LAST.ION . This can be retrieved at any time without interrupting the routine data collection, unless retrieval is requested during a sounding — in this case there will be a wait of up to 12 sec while the sounding completes, since all interrupts are disabled during the data collection.

3.3 'Cleaning' and storing the ionograms

The high-resolution ionograms recorded by the computer originally occupy 36928 bytes (from 577 frequencies x 512 heights). They are compacted into about 7 KB using a modified run-length coding designed for use with the ionogram data. The size of individual compacted ionograms depends on the echoes received, and is greater under noisy conditions or with spread echoes. All data for any one day is stored in a file mmmyy.dd where mmm is the month, yy the year and dd the day (e.g. FEB93.23 for 23-Feb-93). This allows all data for a given month to be copied simply (as FEB*.*), and replay software can step through successive days by incrementing the last number.

To reduce storage most ionograms are 'cleaned' before they are stored in the daily files. This involves (a) deleting data (and graticules) outside the range 1.3 to 16 MHz; (b) deleting all information at heights below 75 km, including the AGC levels; (c) deleting echoes at heights above 700 km at frequencies below 4 MHz, to eliminate the numerical (station, date, time) information on the IPS-42 ionograms; and finally (d) deleting isolated echoes. (d) uses a very conservative algorithm, deleting single pixels only if there are no other echoes within a slanted box extending about 15 pixels above and below, and 3 pixels on either side. This cleaning process halves the storage requirements for the compacted ionograms, to a mean value of about 3.5 kB. Thus each daily file (288 ionograms, with a 5 min recording schedule) occupies about 1 MB. This becomes 0.5 to 0.6 MB when the ionograms are "zipped", or copied to tape in compressed form.

When ionograms are redisplayed by DIGION the frame and all the height, frequency markers are recalculated and plotted as light grey. The 'cleaned' ionograms retain only the top frequency marks at 4, 5.6, 8 and 11 MHz. The recalculated marks are half-length, so the height and frequency scales are readily verified by noting that these cover the top half of the original (yellow) marks.

Ionograms taken nearest the hour are not 'cleaned', so that the full information (date, time, AGC levels and extreme frequencies) is retained. The replay software can readily scan through these full ionograms if required. With this approach, and 5-minute ionograms, all but 1 in 12 of the collected ionograms are cleaned so that the overall storage requirements are still reduced by a factor of about 2. Examples of full and cleaned ionograms are shown in Appendix 3 (b) and (c).

The ionograms to be cleaned can be altered by a third parameter in the initial command line. GETION m 0 n will record ionograms every m minutes, cleaning all but the hourly data when $n = 0$ (the default). $n = -1$ cleans all ionograms, while $n = 1$ cleans no ionograms. $n > 1$ leaves every n'th ionogram uncleaned (starting with one nearest to the hour).

The batch file listed in 3.1 allows the data files to be moved every five days, when GETION exits with errorlevel = 2. The two 'tape' lines write the 5 daily files (about 1 MB each) into a single backup volume on a streaming tape drive. The backup software achieves some further compression, by a factor of generally between 1.7 and 1.85. If you are not using a tape drive, and data is to remain on the hard disk, replace the 'tape' lines by PKZIP %_DATE ???9?.?? . The five files will then be reduced to a single data file of about 3.5 MB, called 27-05-93.ZIP if they are zipped on 27-05-93. One month's data (with 5 min ionograms) will then occupy 15–20 MB of disk space. Note that the file-saving occurs at the end of days 5, 10, 15, 20, and 25, and at the end of the month, so the last file for each month contains data for 3, 4, 5 or 6 days. Each day's data ends at midnight, and the storage date of the 5–day files is the following day. With slow computers writing a 5–day file of 5–min ionograms to tape can take over 5 minutes, so that the first ionogram (at 00:05) on every fifth day is missed.

4 USE OF THE DIGITAL IONOGRAMS

Digital ionograms will normally be stored on tape cassettes in compacted form. We use 'Backup' files each containing 5 daily files, each consisting of 288 ionograms (for 5–minute recordings). This gives reasonably frequent backup, and the files are a convenient size for most purposes. Data for six months fit comfortably on a single 120/240 MB tape. Thus two tapes, swapped monthly so that data can be scaled, will last for over one year. Examination and scaling of ionograms is done on a fast P.C. with sufficient free disk space (about 35 MB) to store one month's un-zipped ionograms. The data are left in compacted form, since the analysis programs can expand this rapidly as required. With a 386 or 486 computer, reading ionograms from disk and expanding them is several times faster than reading uncompacted ionograms (which are larger by a factor of about 10).

Note that all programs are provided on a no-responsibility basis. They are all quite new, being developed for my own work. They have not been checked and polished to commercial standards and are not guaranteed in any way. I will be doing some further developments and modifications, where they look interesting and worthwhile (and easy). So do pass on queries or suggestions — but don't expect anything.

4.1 Surveying the data

A compiled program DIGION.EXE is provided to read data files. There is also a sample data file 02JUN93.ZIP which contains 5–minute ionograms recorded at Auckland on 02-Jun-1993 in packed format. Enter PKUNZIP 02JUN93 to unpack this. Running DIGION, and entering JUN93.02 in answer to the first prompt, will allow you to look at these ionograms using the arrow, Page and Home/End keys as described below.

Source code is provided for all the routines involved in DIGION. These are written in C++ and can be modified as you like for your own requirements, *provided* you share the results with me and with others. Comments in the file DIGION.C describe the linking process. Little analysis software is available at present, but more should slowly become available — or develop your own (and share it).

The program can be started by entering DIGION ; or DIGION filename ; or DIGION filename bitoffset . The third form provides a means of shifting the displayed echoes, in case your ionosonde is giving results with the original graticule (yellow) offset from the computed lines (grey). bitoffset = +1 or -1 will raise or lower all data by one pixel (1.6 km). +512 will shift it up one frequency step (since each frequency has 512 height steps). So 510 will give a shift of one frequency to the right, and two pixels down. The offset can be changed within DIGION by entering 'o' at any time. The program will then list the current offset and ask for a new value. This facility is available but not necessary with version 3.1 hardware (printed–circuit boards) where all time delays are closely controlled.

The program DIGION.EXE is used to examine the collected ionograms, on a daily or monthly basis. It first gives a summary of the stored ionograms, followed by a request for a start number. Just press Enter to begin with the first ionogram. Use the Up/Down arrow keys to progress forward or backward. Ionograms will scroll past continuously as long as the arrow key is depressed (at 2–3 frames per sec, with typical 386/486 computers). The PageUp or PageDown keys show every sixth ionogram (i.e. half-hour intervals, with 5-min data); holding these keys down gives a rapid scan of half-hourly ionograms, stopping at the end of file. Control-PageUp/Down give two-hour steps. Home and End take you immediately to the start or end of the file (moving from start to end can take a few seconds). Control-Home/End take you to the first ionogram on the preceding/following day, provided the corresponding file is available and only the day-number (the file extension) changes. Control-Insert/Delete will, at any time, take you immediately to the corresponding ionogram (at the same local time) on the preceding or following day. This is very useful for checking strange features near sunrise or sunset.

Markers for comparing similar features on different ionograms can be brought up by pushing F1–F4 (frequency marks) or F5–F6 (height marks), as in section 4.2. To list the frequencies and heigh;tds corresponding to teh displayed markers, press 'l'. If you enter an unrecognised key, you will get the request "ionogram number [or Quit] ?" . To cancel this, and continue with the same ionogram, enter '.' as a number which represents the current position (as in MS-DOS).

4.2 Scaling data with DIGION

Pressing any of the function keys F1 to F7 at any time causes you to enter scaling mode (as in Appendix 3(d)). The screen then shows vertical lines (cursors) which are adjusted by the left/right arrow keys, in steps of 1 pixel (0.54%). Control-arrow gives a faster movement, in steps of 8 pixels. The frequency corresponding to each cursor is recorded in a file DIGION.DAT when you move on to the next ionogram, along with the date and time. Press F10 to stop the marker positions being written to a file whenever you change ionograms (or use the shift key, as described below).

F1 or F2 bring up a pair of green or red lines, used to scale the critical frequencies for the E or F layers. The two lines are maintained at the correct separation for the ordinary ray (continuous line) and extraordinary ray (broken line), assuming a height of 120 km for the E region and 300 km for the F region peak. This greatly facilitates accurate scaling, particularly when the trace for one component is curtailed. The gyrofrequency, and the station name shown at the top of the display (and in the output file) are obtained from the unique SITE parameter recorded by GETION at the start of each day's data.

Pressing F3 or F4 brings up a single blue or cyan line, which is used to scale fmin or fEs respectively. F5 or F6 bring up two horizontal lines (light or dark grey), at heights of h and 2h, for scaling h'min or any similar parameter. F6 also gives a line at 3h. The presence of these multiples, which can be checked against 2– or 3–hop echoes, is a great help to accurate interpretation of the data. F7 brings up the standard MUF curve which is moved horizontally by the cursor keys. Any or all of F1 to F7 can be in operation at any time. To turn a parameter off, press the appropriate function key when you are scaling that parameter (or press the function key twice, from any other position); scaling will then shift to the next cursor in sequence. The parameter being scaled is shown by an appropriately coloured block at the top right of the display. To move on to another parameter, press the required function key. Or just press the space bar, to toggle through all currently active parameters in order. When a trace is not clear, hold down the shift key while you press up/downarrow to check an adjacent ionogram; this stops the cursor positions being recorded when you change ionograms.

F10 will toggle the recording of data, which is appended to the file DIGION.DAT . "SCALING" shows in red at the top left when scaled data is being stored. Scaling mode is automatically turned on whenever a new cursor is added (to save the frustration of carefully scaling data which is not saved).

When scaling is turned off (using F10) cursors may be used for comparing different echo traces without recording data. To list (on screen) the frequencies and heights corresponding to the displayed cursors, press 'l'. If the o/x mode separation seems incorrect, you can adjust the gyrofrequency by pressing F9 and entering a new value of FH (at 120 km). The new fx positions will appear ~~only when you use left/right arrow to shift the plotted frequencies.~~ immediately. If your display gets scrambled for any reason, press 'r' to replot the screen. If you wish to adjust the overall echo heights to remove zero errors, enter 'o' to introduce an offset (as in 4.1). An offset of about 3 pixels is often useful to remove the effective error of about +5 km in IPS-42 ionograms, where zero height occurs at the leading edge of the transmitted pulse.

4.3 Time variations with VARION

The availability and easy access of digital 5–min ionograms makes many new types of analysis possible. Thus it is simple to extract data from successive ionograms to show time variations at any required frequency. This is done by the program VARION.EXE . To provide a clean record it extracts soundings at the three nearest frequencies, and assumes a valid return at each height only if echoes occur on any two of the three; this reduces noise and stops blanking by a narrow-band interfering signal.

To run this program for a single day, with ionograms in the file filename , enter VARION m filename freq where freq is the desired frequency (in MHz). Results from any number of frequencies can be superimposed, using VARION m filename f1 f2 f3 .... fn . m is the number of consecutive days which are to be plotted, on one page. This will commonly be 1, 2 or 4, but can be 30 for a full month's plot (showing only a limited height range). The time taken is about 3 secs per day to analyse and plot the data. Plots for successive periods, of m days, are obtained by tapping the space-bar; any other key terminates the program.

Heights at successive frequencies are plotted in red, blue, green, red, blue, green,... as shown by the colours in which the frequencies are listed above the plot (Appendix 3(e)). Other colours are produced where echoes overlap, giving magenta from red + blue; cyan from blue + green; yellow from green + red and white from red + blue + green. To reduce confusion, an edge-detection algorithm is normally used to limit the number of displayed points; this can be over-ridden by entering a negative value for m , to give a plot showing all heights at which a given frequency was reflected.

4.4 [Real height profiles with RELION — scaling and N(h) analysis using POLAN. TO DO]

Appendix 1. – SCREEN OUTPUT from a dummy GETION run

```
{---MESSAGE---}        {enter "getion"  and press return}        {---EXPLANATION---}
   DIGION system,  used with an IPS-42 ionosonde
   Version 3.  Copyright 1993 by J.E. Titheridge
   Physics Dept.,  University of Auckland,  N.Z.

Computer Date= 13-04-93;  Time= 16:56:10.
Are these within +/-30s of the ionosonde time [Y or N]?              {enter "y" only}

Enter the desired time interval between soundings ?
 [1, 2, 3, 5,...,60 minutes.   Default = 5 mins] 97                 {enter "97",return}
 Run with full listings.  Will use data file APR93.13             {A new or existing file}

Entering reset:  Ports are initialised.
Computer Date= 13-04-93;  Time= 16:56:16.
Waiting to sync with ionosonde:   MIN high; WAITing to go low....[kbd->cont]
                                   {Press any key to simulate the WAITed signal}
System is reset. - Leaving reset.          {Computer time is now synchronised}
Entering disk INITIALISE() routine.
Ionograms on APR93.13:    {or "File APR93.13 is empty but in use." if no existing data}
No.       DATE          TIME          FREQUENCIES   HEIGHTS   BYTES
1       13/04/1993     15:31:43       1       577      64      5648
2       13/04/1993     15:35:14       1       577      64      5648
This is the currently used data file.
Times from INITIALISE(), as set in SYNC():
  Date= 13-04-93.  Time= 16:57:00.
  Leaving INITIALISE().
CONTROL() at 16:57.   WAIT to next Sweep-Time(*97 min) [or kbd]...          {###}
                                          {Press any key to initiate a sweep}
  Keyboard Sweep Request: Now.
In GETSCAN(); -> VIDSCAN.
  VIDSCAN() freqs 1 to 577, height= 64 bytes.               {64 bytes = 512 pixels}
   ->WAITSOUND():Trigger Sweep.  WAIT for Y ->Low (at 0,20,40s)...[kbd->cont] {any key}
   ->SOUND in 2 secs... MODEL DATA at F= 1 8 15 22 29 36 43 50 57 64 71 78 85 92
99 106 113  {...  ...}  561 568 575 : Freqs 1 to 577 recorded.
Leaving VIDSCAN().         {The next line occurs only on the 1st ionogram in each hour}
Re-synchronise clocks in Getscan:  MIN high; WAITing to go low....[kbd->cont] {any key}
                                   {You then have 4 sec to read the following:}
Saving data;  then Display.
Compact 36928 to 5479 bytes.            {These are the sizes for the dummy ionogram}
    {The ionogram now displays on a new screen.  At the top of the ionogram, appears:}
CONTROL() at 16:59.   WAIT to next Sweep-Time(*97 min) [or kbd]...
                                 {Enter esc, control-C or control-Break to end.}
              {Any other key will start the next sweep: repeating from {###} above:}
In GETSCAN(); -> VIDSCAN.
  VIDSCAN() freqs 1 to 577, height= 64 bytes.
   ->WAITSOUND():Trigger Sweep.  WAIT for Y ->Low (at 0,20,40s)...[kbd->cont]
           {enter any key to simulate the '20-sec' pulse for next sweep..,  etc...}
```

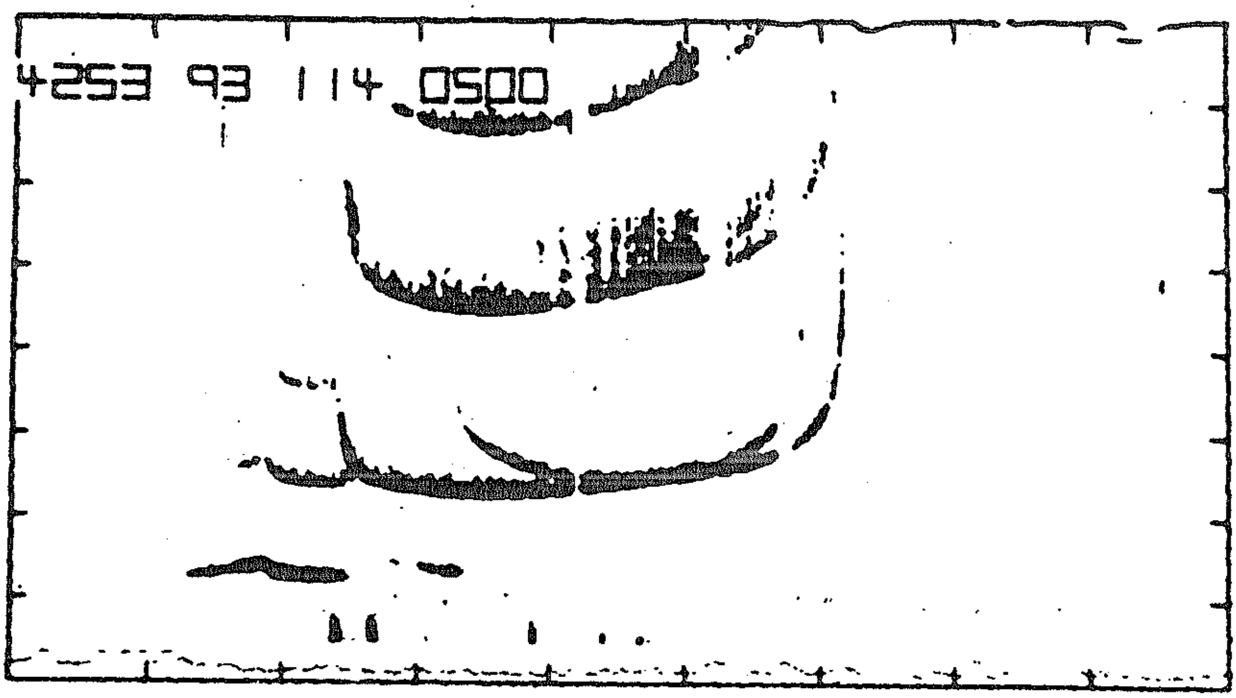
Appendix 2. – ERROR CODES

As returned by GETION and DIGION .

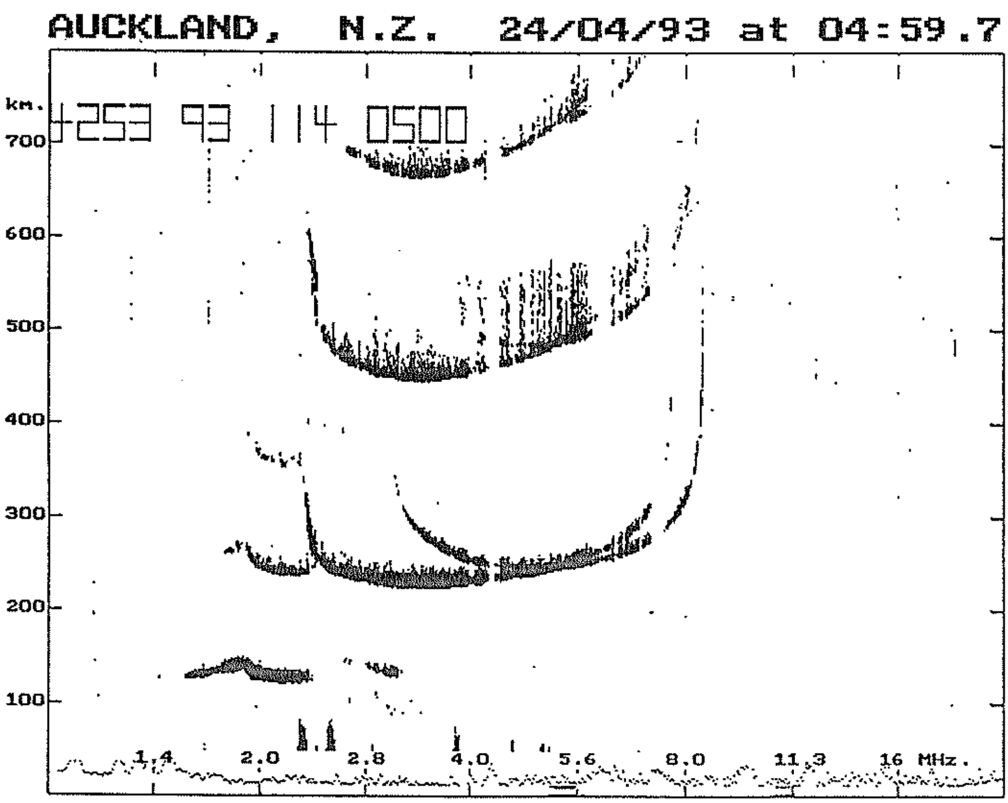
```
// Miscellaneous
#define ABORT         0   // used in exit() call of panic().
#define RESTART       1   // used in exit() call of panic().
#define MAXERRORS     10  // Number of re-tries before giving up.
#define MMARGIN       16  // Add to uncertain malloc's for safety.

// Errors related to the initial control part.   1 - 9.
#define EDATE         5   // Illegal date given to setdate() <time 103>
#define ETIME         6   // Illegal time given to setdate() <time 110>
#define ENOTIME       7   // Time file is not created or creatable<time 137,38>
#define EBADTIME      8   // Time file is corrupted <time 123,127>

// Errors from hardware (data collection) part. 10 - 39
#define EISDEAD       10  // Signals fail in SOUNDS.ASM,  amplified by:
       ////ernum=     11: initial Y was high.       12: Y stays low.
       ////        13,14: DataRdy stays Low,High.   15: DataRdy stops toggling.
#define EDEAD         20  // Signals dead <from waithi, waitlo>
#define ESTARTED      21  // Y high on entry to sound (data already started?)
#define EISHIGH       22  // Signal is already high <waithi, from time.33>
#define EISLOW        23  // Y signal already low <waitlow; time38, scan80,113>
#define ESRATE        24  // Illegal sample rate (height) given to getscan.

// Errors from data storage and retrieval part. 40 - 59
#define ENODAT        40  // No ionogram data file (bad open) <disk1,2>
#define EBADDAT       41  // File exists but is corrupt.
#define EFULL         42  // Datfile is (already) full.
#define ENOWRITE      43  // Can't write to data file.
#define EINUM         44  // Requested ionogram number too large.
#define EDISP         45  // Illegally short disp byte, expand().
#define ETRIM         46  // File has been trimmed (recheck); or no ionograms.
#define ENEW          47  // "Soft" errors: new current file made,
#define ECURRENT      48  // This is current file.
#define EDISK         50  // Can't make data file.
```

Appendix 3. – TYPICAL RESULTS

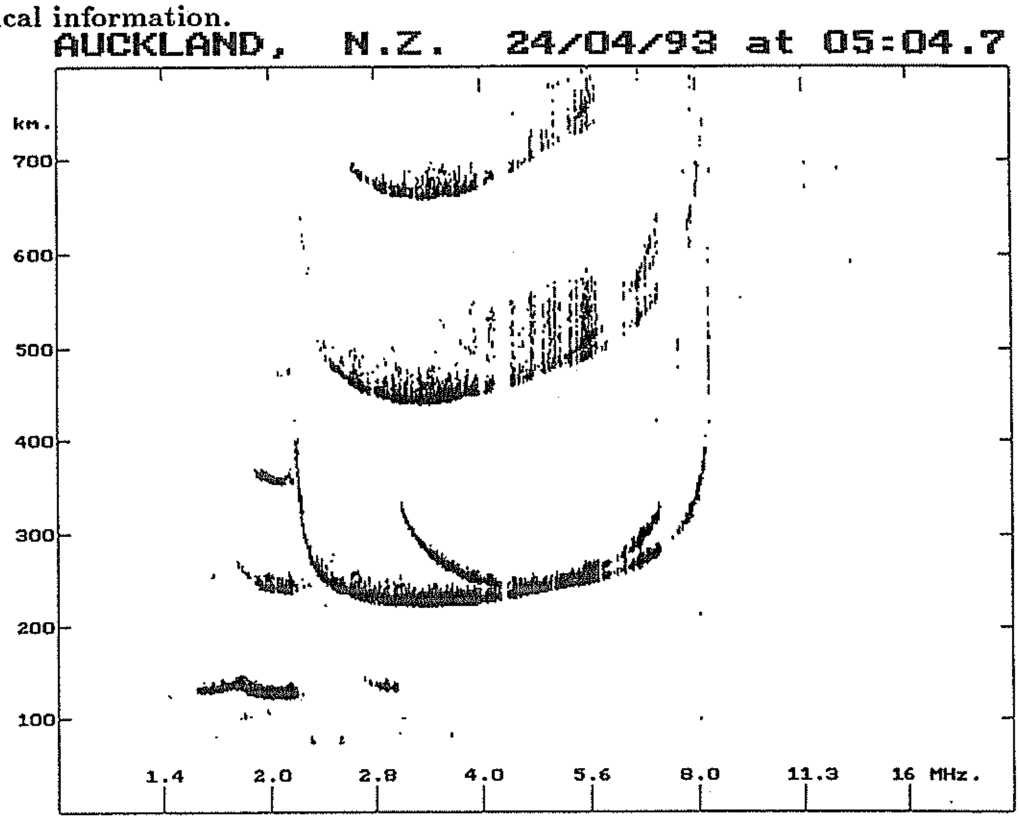
(a) The result from a good film ionogram (sharply focussed and correctly exposed).



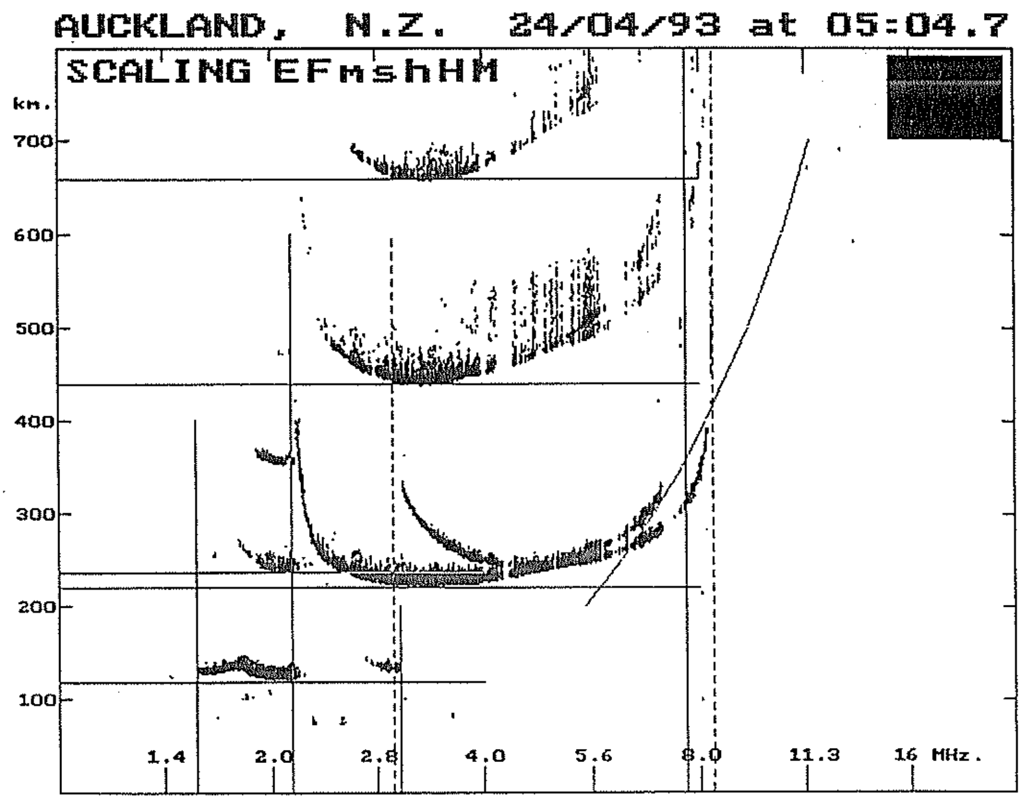
(b) The same ionogram as (a) recorded by DIGION. This occupies 37 kB in its original form and 7 kB when compacted (with no loss of data).



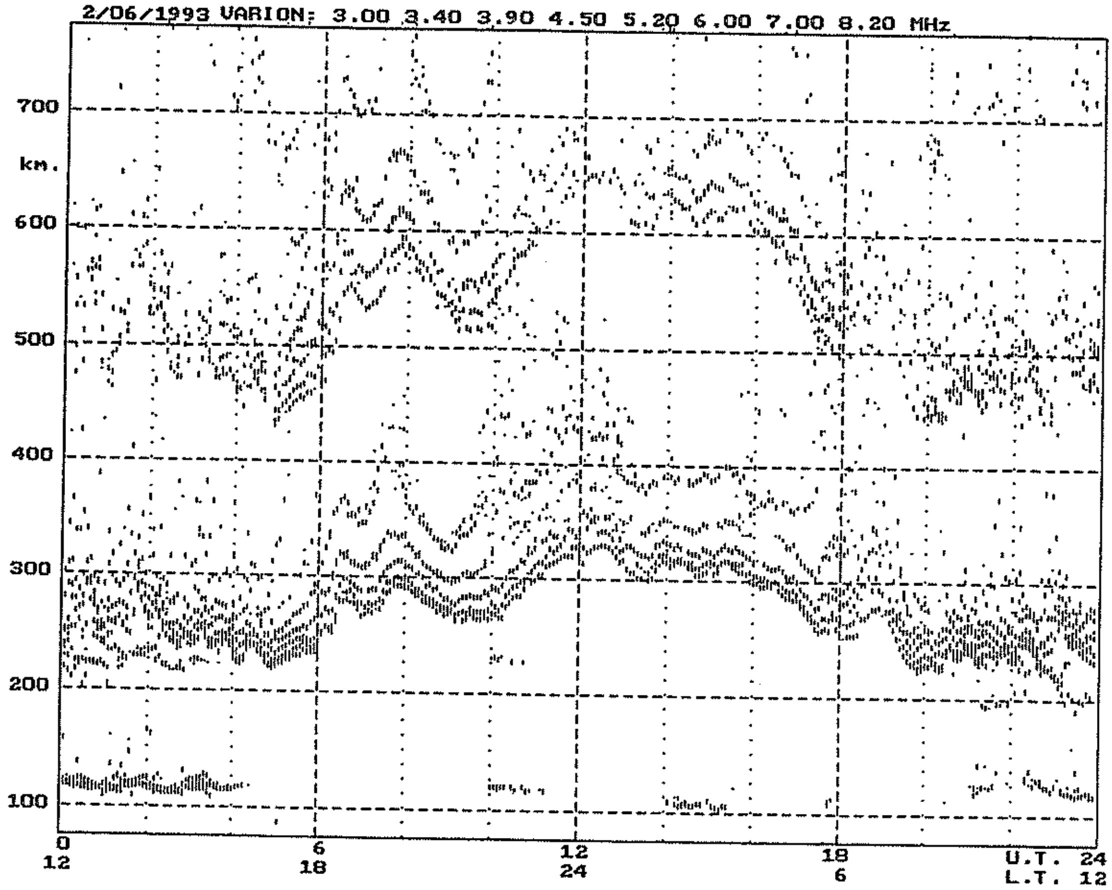
(c) Hourly ionograms are stored in full, as in (b) above. This is the next ionogram which has been "cleaned" to reduce storage to about 3.5 kB. Cleaning removes all echoes below 1.3 or above 16 MHz; below 75 km; or in (or above) the area occupied by the numerical information.



(d) The ionogram (c) displayed by DIGION with lines for scaling foE, foF, fmin, fEs, hminE, hminF and MUF(3000). Critical frequencies are shown for the O ray (continuous lines), along with the corresponding value for the X ray (broken lines) calculated using the correct gyrofrequency for each layer.



(e) Plots produced by the program VARION, to show the time variations in the echo heights at a number of fixed frequencies. In the original plots the results at different frequencies (listed above the display) are shown in different colours.



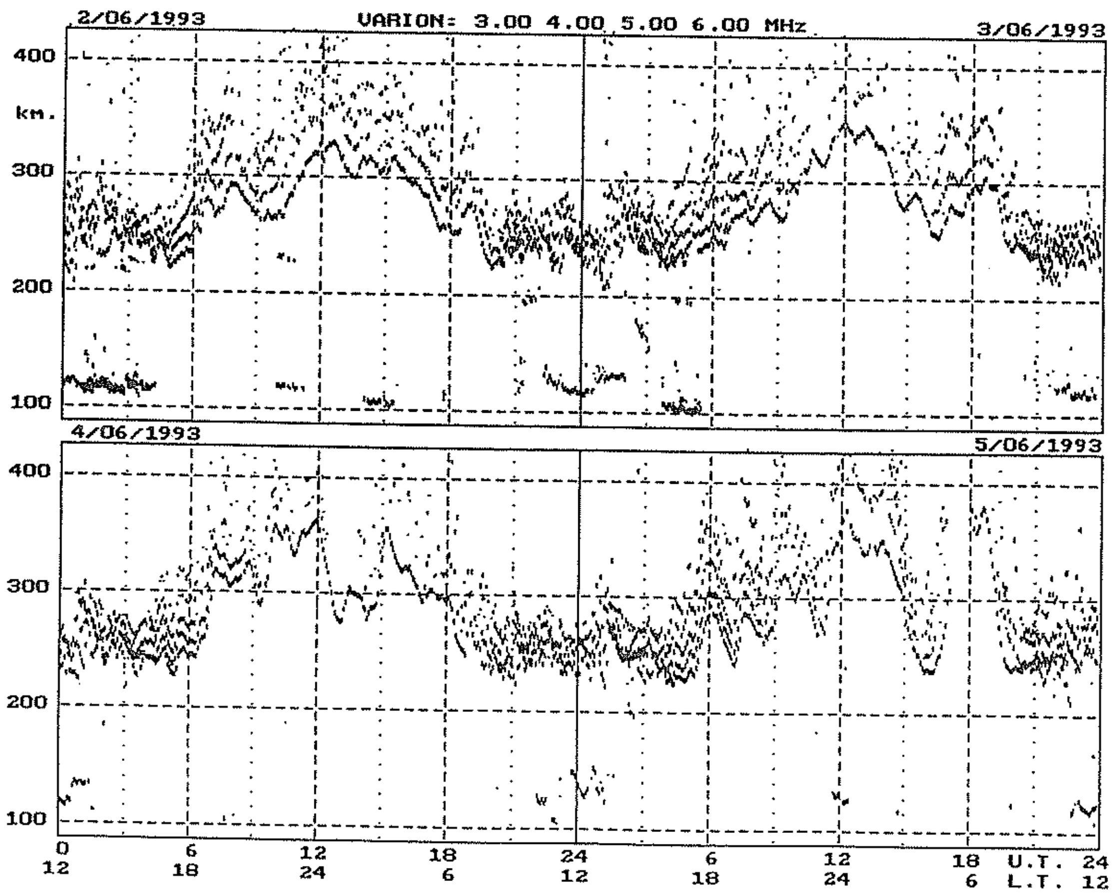
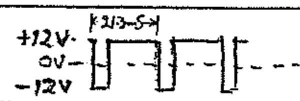
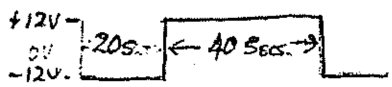
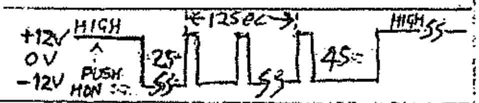
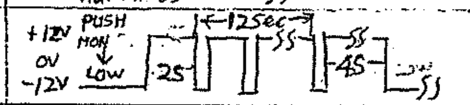
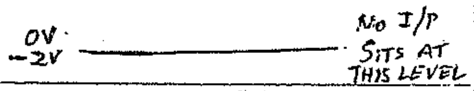
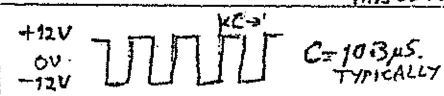
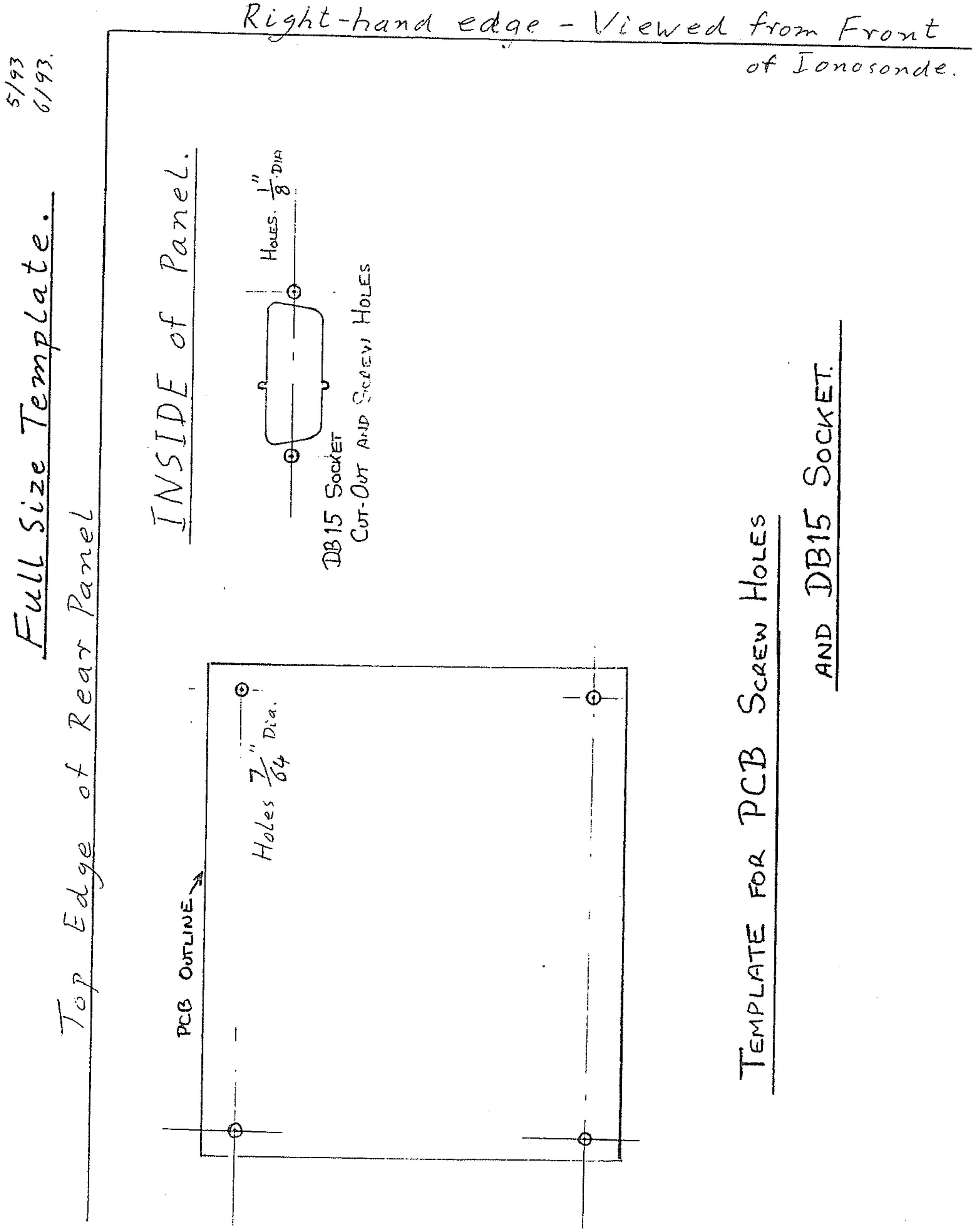


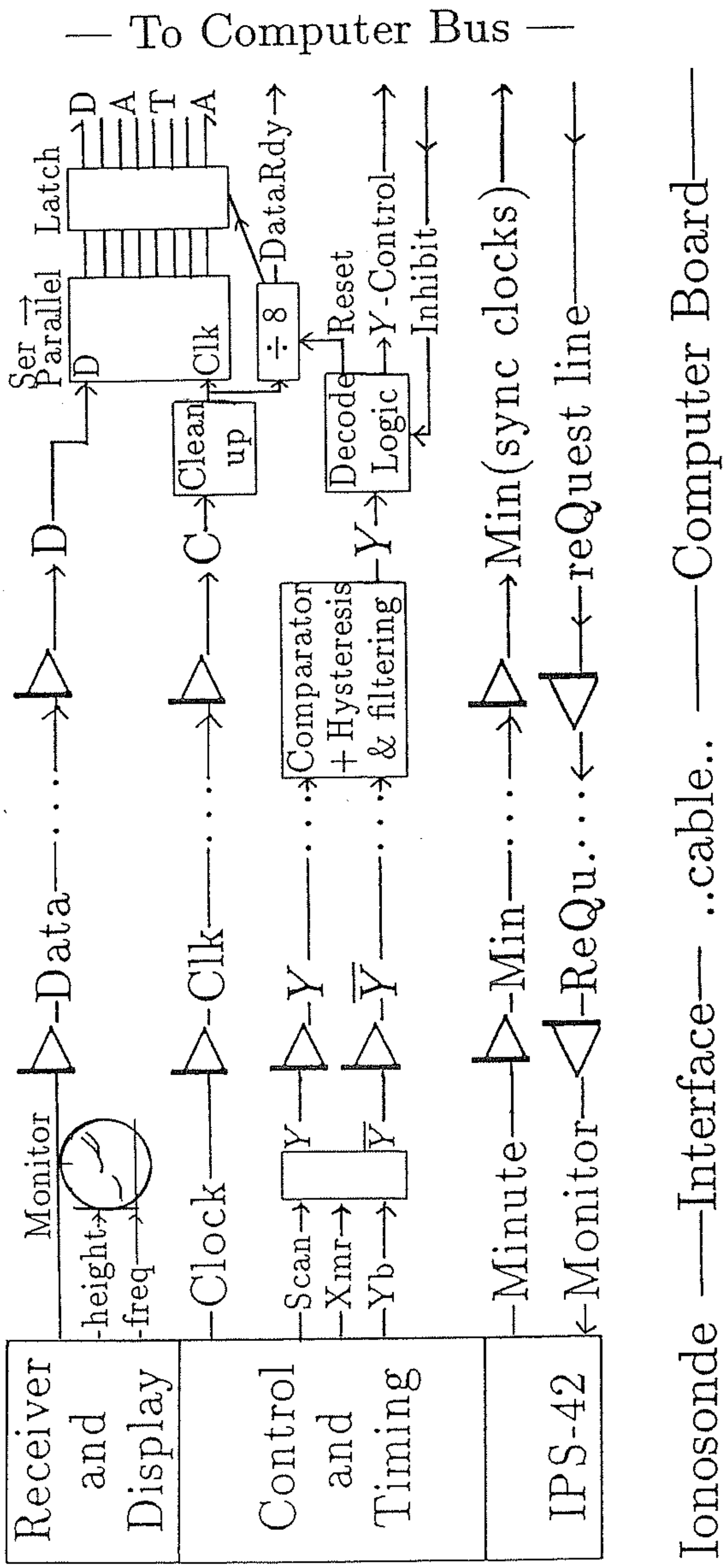
TABLE 2. SIGNALS ON THE DB15 SOCKET

PIN No	SIGNAL	WAVESHAPE.
1	SIGNAL GND.	OV.
2	DATA	
3	MINUTE.	
4	$\overline{Y}$	
5	Y	
6	MONITOR REQEST	
7	CLOCK	
8	SIGNAL GND	OV.
9 TO 15	SIGNAL GND	OV

MOUNTING THE INTERFACE BOARD AND DB15 socket inside the rear panel of the IPS-42 ionosonde.



Appendix 4. – HARDWARE – Overall Block Diagram

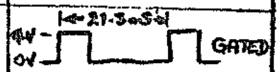
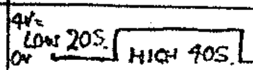
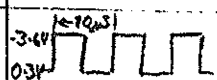
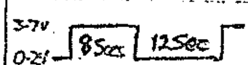
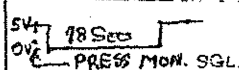
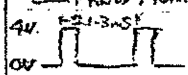


Appendix 5. – THE INTERFACE BOARD in the Ionosonde

TABLE 1A. THE POWER CONNECTIONS

+12V	12·12V	BD 18 PIN 3	RED	
−12V	−11·99V	BD 18 PIN 2	BLACK	
+5V	5·06V	BUSS PIN 17	YELLOW	
SIG. GND.	–	BUSS PIN 1	GREEN	

TABLE 1B. THE SIGNAL CONNECTIONS

PCB PAD		ORIGIN /DESTINATION	COLOUR	SIGNAL
1	DATA	BD 8 PIN 18	BLUE	
2	MINUTE	BD 5 PIN 10	BROWN	
3	—			
4	—			
5	CLOCK	BD 5 PIN 27	RED	
6	—			
7	XMR	BD 8 PIN 31	ORANGE	
8	SCAN	BD 17 PIN 30	BLACK	
9	YB	BD 8 PIN 3	WHITE	
10	—			
11	MON. RESET	BD 17, IC8 PIN 1	GREY	HIGH; GOES LOW (0V) ON PRESSING MON. SGL.
12	—			
13	—			

Ionosonde IPS-42 – Installation Instructions

for Interface Board Series Z-0493-xx

Updated 05/97

Note: The interface board supplied has been tested
in an operational ionosonde before despatch.

1. Check the parts received:– 1x P.C. Board (type Z–0493–13) with attached leads
   1x DB15 socket skirt, and mounting hardware
   1x set of 4 mounting bolts, with spacers

2. Read these installation instructions in full and when conversant with each step of the procedure, assemble the following equipment:–
   Oscilloscope (1 MHz is adequate)
   Multimeter
   KEL IPS-42 Technical manual
   IPS-42 extension cable, with 16-pin Amphenol connectors
   Drill and bits (2.8mm, 3.2mm) for 6 mounting holes
   Nibbler tool (or other) for making the DB15 cut-out
   Files, flat and triangle, for shaping the DB15 cut-out
   soldering iron (for one joint)
   screwdrivers, adjustable spanner,..

3. Shut down the ionosonde equipment by turning the transmitter output to 'off' and disconnecting both the mains power and the battery supply.

4. Remove the top chassis (containing the digital plug-in boards) from the main cabinet.

5. Place this chassis on a workbench and verify the position of each "plug-in" board (refer to Table 1B attached) that requires connection to the interface board. Verify by sighting the board numbers, as the boards may not be in numerical order. When found, for future reference, write the board numbers on the chassis frame above each board's socket.
   The 33–pin sockets have two rows of wire-wrap pins extending from them. Viewed from the rear of the units, the left hand row holds the odd numbers 1 (top) to 33 (bottom), while the right hand row is pins 2 to 32. Wire-wrapping produces a common buss of some of these pins, e.g. pin 1 = signal ground, pin 17 = + 5 volts.

6. With the chassis at the rear or alongside the ionosonde equipment, unscrew the left hand rear panel (see Figure 1) from the unit. Slide along the cables that pass through it, so that the chassis may be placed flat on a work bench without disconnecting these cables.

7. Use the 16-way Amphenol extension cable to connect socket SK1 (see Figure 1) back to the plug PL1 on the cable loom at the rear of the ionosonde. This action provides the unit with a +/– 12 volts supply. Where no extension cable is available, the unit may be operated satisfactorily on a workbench using a 24 volt, 2 amp power supply connected via SK1.

8. Apply power to the unit by turning the ionosonde on (or from your bench power supply). Use the oscilloscope to find and verify that the signals to be connected to the interface board are present at the appropriate pins. The name of each signal, the pin on which it appears, and the signal wave-form are listed in Table 1B.
   Note: The Monitor Switch S2 is set to "Single" sample rate. The "Monitor Single" push-button switch (S3) must be pressed to display some of the waveforms in Table 1B.
   If there is any doubt as to whether or not the correct pin has been identified, on a particular board socket, the appropriate circuit diagram in the KEL technical manual should be consulted. The signal path to a particular pin can also be verified on the unplugged board.
   Once found, the pins that are to be used for the interface could be marked with a dab of paint, a short piece of slip-on plastic tubing, or some other means (but note that the end must be kept clean for the connectors).

9. Disconnect power to the unit. Drill and cut out the aperture for the DB15 socket, and holes for mounting the socket and interface board, using the template in Figure 4.

10. Mount the interface board on the inside of the rear panel, with the flat cable and socket attachment point nearest the top of the panel (see Figure 2). Run the flat cable between the interface board and the rear panel, to the DB15 aperture. Mount the DB15 socket by first passing it through the slotted aperture before securing it along with an RF skirt to the rear panel.

11. Stand the rear panel upright and secure it to the chassis with two or three screws (finger tight). Fit the ten wires with sockets on their ends from the interface board to the appropriate pin on the board sockets (previously verified from Table 1B).

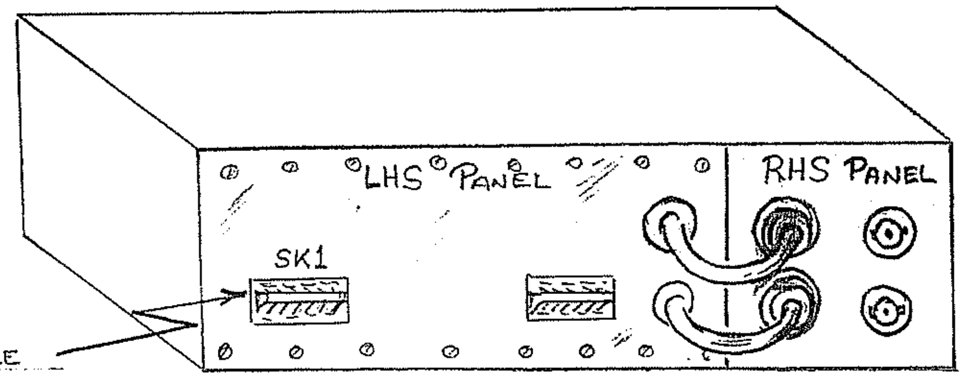
12. The remaining grey wire is now broken at the "in-line" connector. The section not connected to the interface board is soldered to plug-in board 17, which is mounted on a sub-chassis containing the "Main" and "Monitor" rotary switches. Remove this sub chassis from the unit to identify the connection point, at the junction of IC8 pin 1 and one side of the "Monitor Single" push button switch (S3). The most convenient point to attach the grey wire is at a test point adjacent to IC8. The free end of the grey wire is soldered on here. Replace the sub-chassis in the unit, reconnect the in-line plug and socket, and test continuity between IC8 pin 1 on Board 17, and pad 11 ("Q") on the interface board.

13. Reapply power to the unit via SK1, and check the voltage levels (+12, –12 and +5 volts) on the interface board. These could vary by several percent in different ionosondes; if changes are greater than this, find out why. If satisfactory, continue by testing the signals out of the DB15 socket (use a piece of wire clipped in an oscilloscope probe). These levels and waveforms should be as indicated in Table 2, remembering that signals leaving the ionosonde are inverted at this socket by the line driving chips.

14. Remove power from and reassemble the unit. Reinstall the chassis in the IPS-42 cabinet, and refit all panels and knobs. Complete the installation by applying power to the ionosonde, and check again that the correct signal levels and waveforms are present at the DB15 output socket.

Fig. 1.

Digital Plug-Ins Unit
(Rear View)



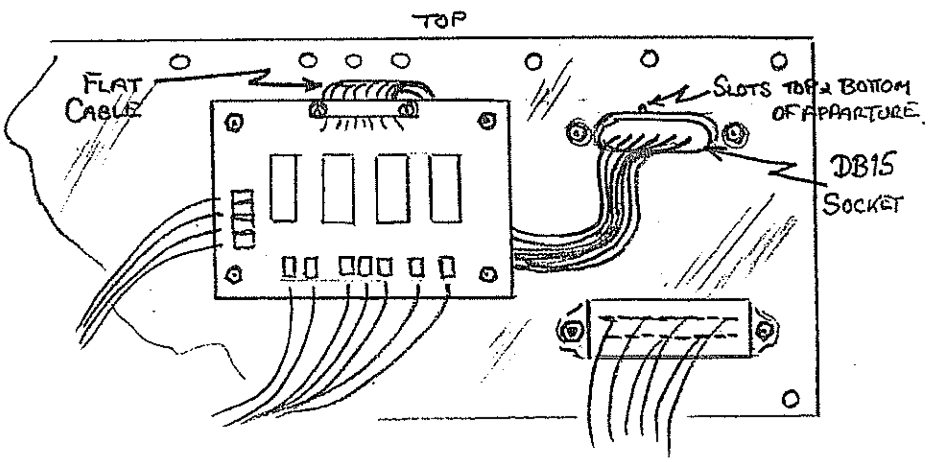
SK1 Socket
Is a 16 pin Female
Amphenol Socket to which
the 24 Volt supply is connected.

Average current drawn
by this unit = 1·6 Amps.

Fig. 2.

Rear LHS Panel

Viewed from the inside
with I/F Board and DB15
socket mounted.



THE IONOSONDE INTERFACE BOARD.

THE POWER CONNECTIONS <u>TABLE 1A.</u>

+12V	12.12V	BD 18 PIN 3	RED	
−12V	−11.99V	BD 18 PIN 2	BLACK	
+5V	5.06V	BUSS PIN 17	YELLOW	
SIG. GND.	−	BUSS PIN 1	GREEN.	

THE SIGNAL CONNECTIONS <u>TABLE 1B.</u>

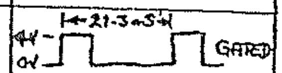
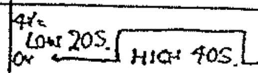
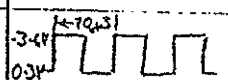
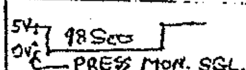
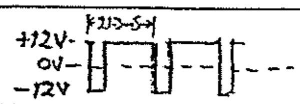
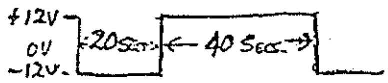
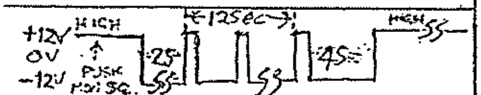
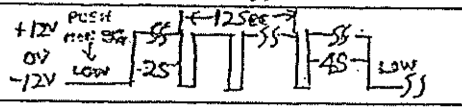
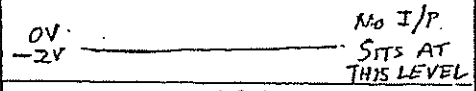
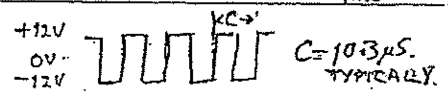
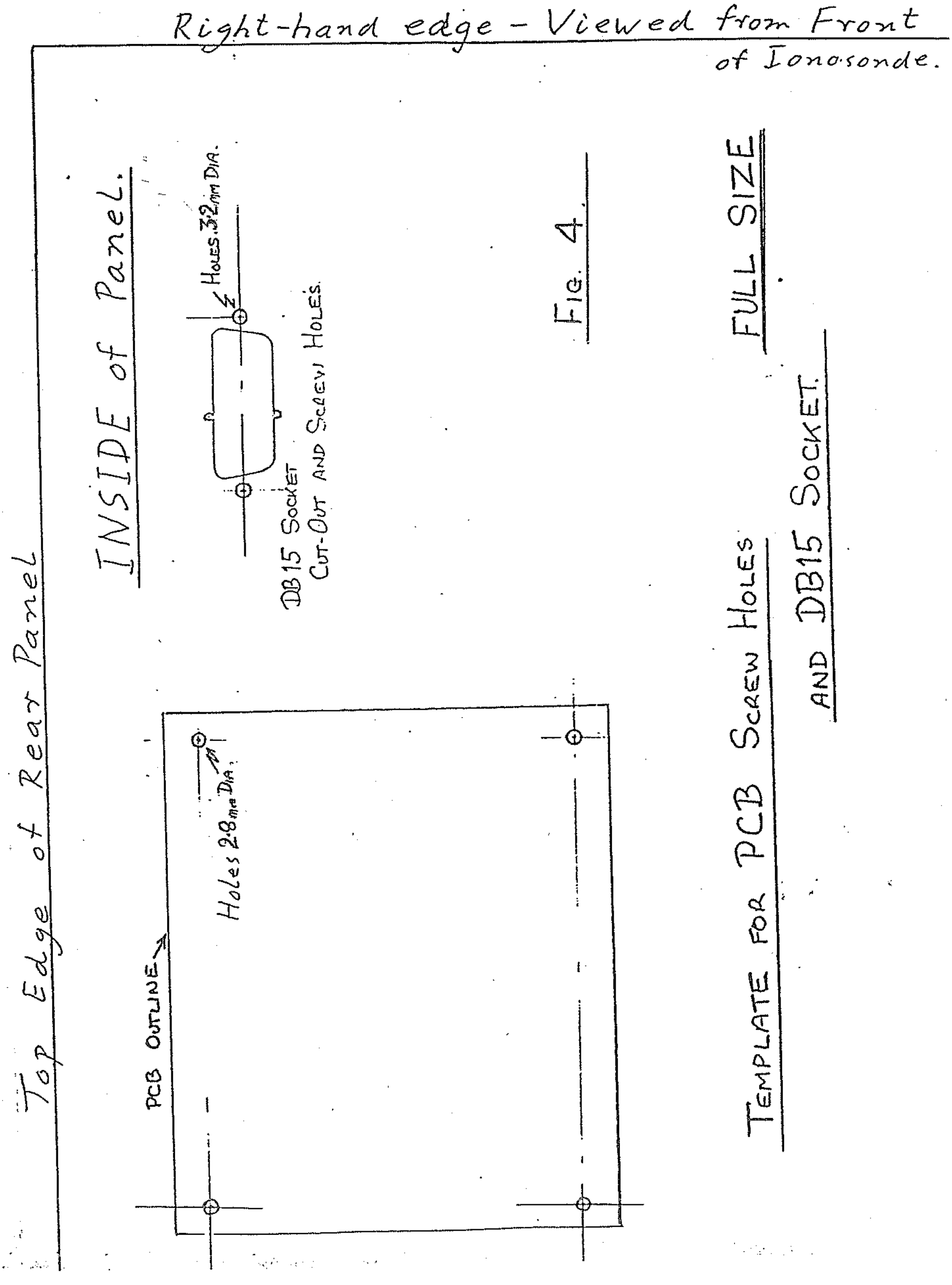
PCB PAD		ORIGIN /DESTINATION	COLOUR	SIGNAL.
1	DATA	BD 8 PIN 18	BLUE	
2	MINUTE	BD 5 PIN 10	BROWN	
3	—			
4	—			
5	CLOCK	BD 5 PIN 27	RED	
6	—			
7	XMR	BD 8 PIN 31	ORANGE	
8	SCAN	BD 17 PIN 30	BLACK	
9	YB	BD 8 PIN 3	WHITE	
10	—			
11	MON REQST	BD 17, IC8 PIN 1	GREY	HIGH; GOES LOW (0V) ON PRESSING MON. SGL.
12	—			
13	—			

TABLE 2.

SIGNALS ON THE DB15 SOCKET SK1.

Pin No	Signal	Waveshape.
1	Signal Gnd.	OV.
2	Data	
3	Minute	
4	$\overline{Y}$	
5	Y	
6	Monitor Reqest	
7	Clock	
8	Signal Gnd.	OV.
9 to 15	Signal Gnd	OV

MOUNTING THE INTERFACE BOARD AND DB15 socket inside the rear panel of the IPS-42 ionosonde.



INSTALLATION OF INTERFACE BOARD Z-493-11

The interface board supplied has been tested in an operational Ionosonde IPS-4B before despatch.

1. Check the parts received:

   1 x PCB complete
   1 x DB15 socket skirt and mounting hardware
   1 x Set of PCB mounting hardware
   1 x Set of Installation Instructions
   1 x Installation Kit

2. Read the Installation Instructions in full and when conversant with each step of the procedure to be followed to install this interface board, assemble the following test equipment:

   1 x Oscilloscope, 20 MHz or better
   1 x Multimeter
   Hand tools including soldering iron (temp. controlled), wire strippers, screwdrivers (range), side cutters, pliers and adjustable spanner.
   1 x 24 volt, 2 amp regulated power supply is desirable but not essential.
   1 x IPS-4B Technical Manual.

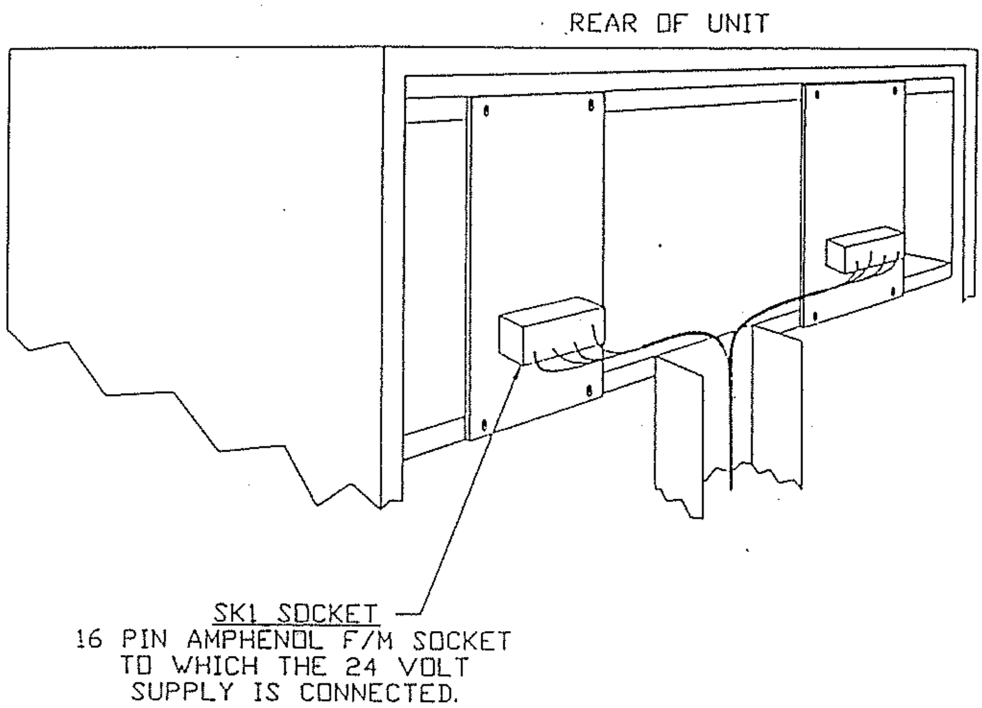
3. Shut down Ionosonde Equipment by disconnecting both the mains power and battery supply.

4. Remove the top chassis (containing the digital plug-in boards) from the main cabinet.

5. Place this chassis on a workbench and verify the position of each "plug-in" board (refer to Table 1B in appendices) that requires connection to the interface board (sight the board numbers, as the boards may not be in numerical order). When found, write the numbers on the chassis frame above each board's socket for future reference. The 33 pin sockets have two rows of wire-wrap pins extending from them. Viewed from the unit's rear, the left hand row holds the odd numbers 1 to 33 (top to bottom) while the right-hand row holds pins 2 to 32. Wire wrapping produces a common loss of some of these pins.

6. Using a 24 volt 2 amp regulated power supply or the power cable in the installation kit connected between your ionosonde's PL1 plus and socket SK1 on the rear of the chassis you now have on your workbench, to supply the unit with power.

Connection of power to the unit must only be made to socket SK1 shown in Figure 1 below:



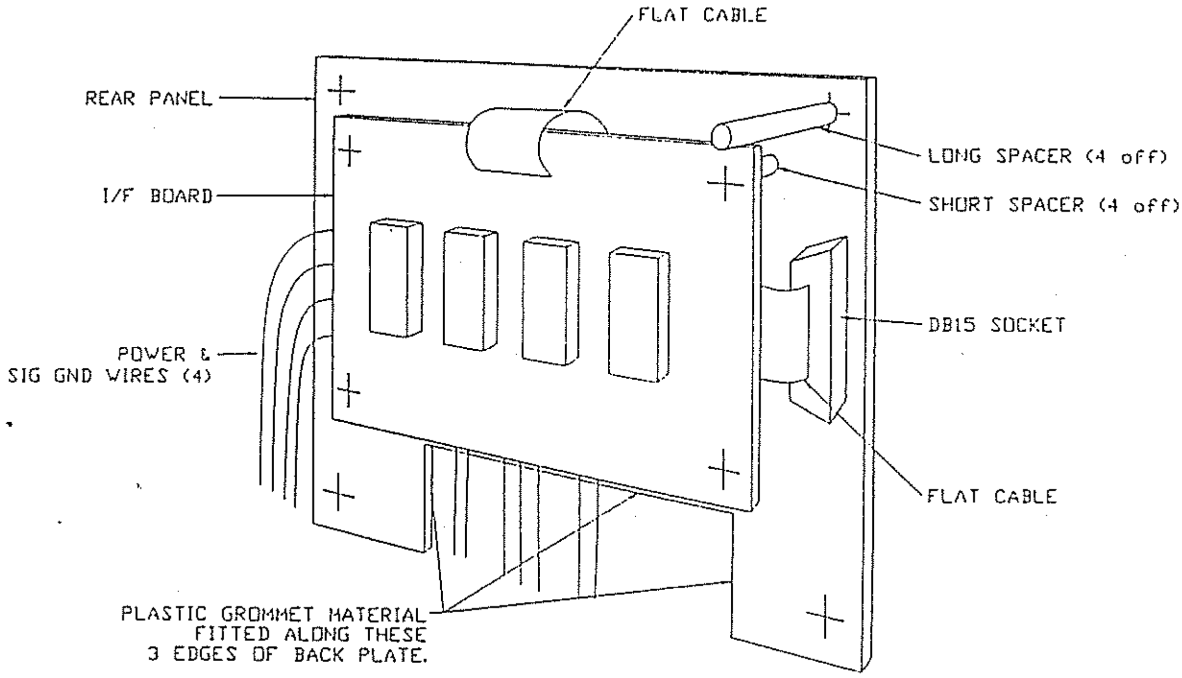
7. Apply power to the unit from either a power supply or your ionosonde via the extension cable from the kit. Now using an oscilloscope, find and verify that the signals to be connected to the interface board are present at the appropriate pins (for pin/signal, wire colour, origin and destination of signal, see Table 1B). Having verified the correct signals are present, switch off and disconnect the power source.

   NOTE:
   The Monitor Single, push-button switch (S3) must be pressed to display some of the waveforms in Table 1B (Monitor Switch S2 set to "Single").

If there is any doubt as to whether or not the correct pin has been identified on a particular board socket, the appropriate circuit diagram in the IPS technical manual should be consulted and the signal path of the pulse/level concerned verified on the unplugged board.

8. Disconnect power to the unit. Then unscrew the left-hand rear cabinet opening (see Figure 1 above) from the chassis, slide along the two cables that pass through it so that it may be placed flat on a workbench without disconnecting these cables. Drill and cut out the aperture for the DB15 socket (see Template) and holes for mounting the socket and interface board from the recommendations in Figures 10 and 11 and templates provided in the appendices.

9. Mount the interface board on the inside of the rear cabinet opening with the flat cable and socket attachment point nearest the top of the cabinet opening (see Figure 2).



Run the flat cable between the interface board and the rear cabinet opening to the DB15 aperture and mount the DB15 socket by first passing it through the slotted aperture before securing it with an RF skirt to the rear cabinet opening.

10. Stand the rear panel upright and secure it to the chassis with two or three screws (finger tight). Fit the nine wires with sockets on their ends from the interface board to the appropriate board socket pin (previously verified from Table 1B). The two remaining wires (grey and black) may now be broken at the "in-line" plug and socket. The sections not connected to the interface board must now be soldered to plug-in board 17, which is mounted on the sub-chassis containing the Main and Monitor rotary switches. This is achieved by removing the sub-chassis from the unit and identifying each test point, to which a wire is to be connected in turn:

(a) the grey wire (monitor request line) is soldered to the test point connected to pin 1 of IC8 and one side of the Monitor pushbutton switch

(b) the black wire (scan level) is soldered to the test point connected to pin 10 of IC7.

Having made these connections, replace the sub-chassis in the "in-line" plugs and sockets for these signals back to the interface board.

11. Re-apply power to the chassis via SK1 and monitor the voltage levels on the interface board which are typically:

+ 12.1 volts
-12.0 volts
+5.1 volts

If satisfactory, continue (if not, find out why) by testing the signals out of the DB15 socket. These levels and waveforms should be as indicated in Table 2B, remembering that pulses leaving the Ionosonde will be inverted at this socket by

the line driving chips.

Remove power from the equipment and reassemble chassis. Reinstate chassis in the equipment cabinet and refit all panels and hooks removed to allow modification to chassis.

To complete the installation, re-apply power to the Ionosonde and check the signal levels/shapes are present at the DB15 output socket.

TABLE 1. THE IONOSONDE INTERFACE BOARD.

1A. THE POWER CONNECTIONS

+12V	12·12V	BD 18 PIN 3	RED	
−12V	−11·99V	BD 18 PIN 2	BLACK	
+5V	5·06V	BUSS PIN 17	YELLOW	
SIG. GND.	–	BUSS PIN 1	GREEN.	

1B. THE SIGNAL CONNECTIONS

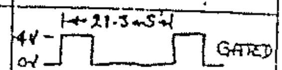
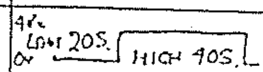
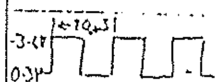
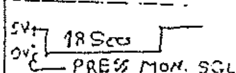
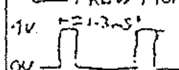
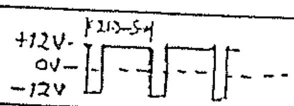
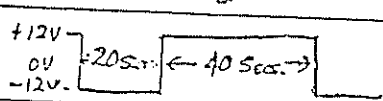
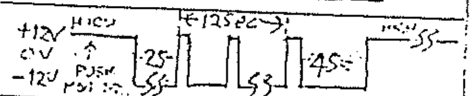
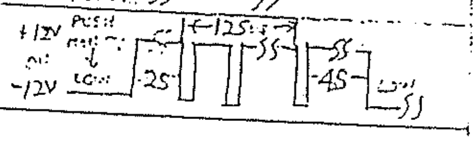
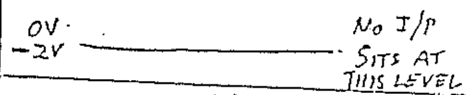
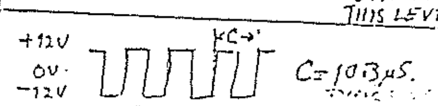
PCB PAD		ORIGIN /DESTINATION	COLOUR	SIGNAL.
1	DATA	BD 8 PIN 18	BLUE	
2	MINUTE	BD 5 PIN 10	BROWN	
3	—			
4	—			
5	CLOCK	BD 5 PIN 27	RED	
6	—			
7	XMR	BD 8 PIN 31	ORANGE	
8	SCAN	BD 17 PIN 30	BLACK	
9	YB	BD 8 PIN 3	WHITE	
10	—			
11	MON! RESET	BD 17, IC8 PIN 1	GREY	HIGH; GOES LOW (0V) ON PRESSING MON. SGL.
12	—			
13	—			

TABLE 2. SIGNALS ON THE DB15 SOCKET

PIN No	SIGNAL	WAVESHAPE.
1	SIGNAL GND.	OV.
2	DATA	
3	MINUTE	
4	$\overline{Y}$	
5	Y	
6	MONITOR REQEST	
7	CLOCK	
8	SIGNAL GND	OV.
9 TO 15	SIGNAL GND	OV

The University of Auckland

Associate Professor J. E. Titheridge
(Senior Research Fellow)
Telephone (64 9) 373 7599 (ext. 8866)
Facsimile (64 9) 373 7445
E-Mail: J.TITHERIDGE@AUCKLAND.AC.NZ

Department of Physics
The University of Auckland
Private Bag 92019
Auckland 1, New Zealand

16 December, 1998

University of Auckland — DIGION System

as supplied on 17 December 1998, to:–

IPS Radio and Space Services

P.O. Box 5606, West Chatswood,

NSW 2057, AUSTRALIA

1. 1x Personal Computer Driver Board — Type Z-0993-11 — Serial No. 36 [✓]

2. 1x Ionosonde Interface Board — Type Z-0493-13 — Serial No. 36 [✓]

3. 1x Connecting Cable, Ionosonde to PC, — Type PC 4203 [✓]

4. Hardware, for:
   a. Interface Board (to mount in IPS-42) — 4x 6 BA bolts, nuts and spacers [✓]
   b. DB15 socket (to mount on panel) — 2x 1/8" bolts and metal skirt [✓]
   c. RFI suppressers (mounted on cable) — 2x clip-on ferrites [✓]

5. 2x Manual (24 pages) for the A.U. DIGION System
   Version 3.1, March 1994 [✓]

6. 2x Installation Instructions (6 pages) for mounting the Interface Board [✓]

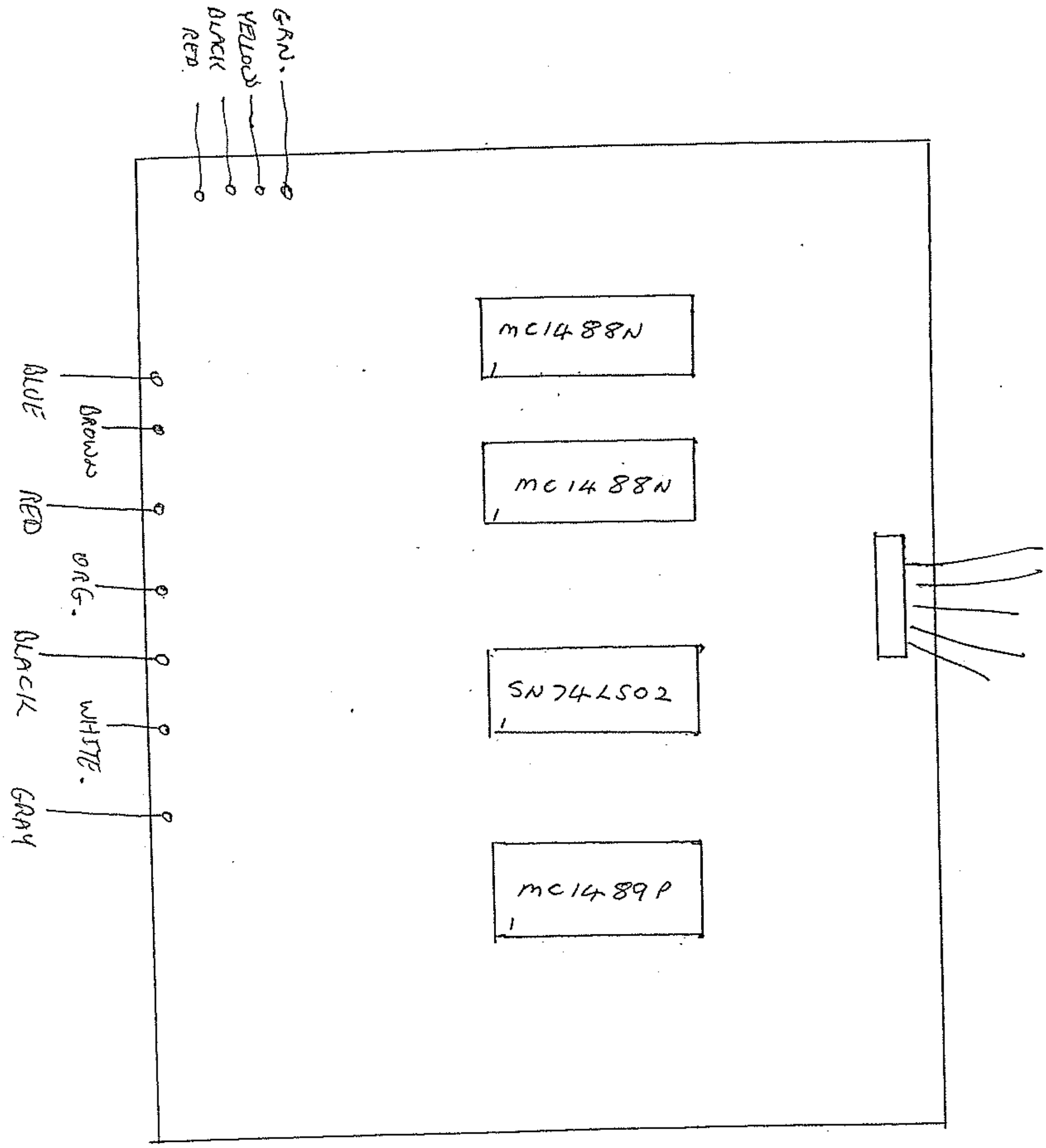
7. 2x Floppy Disk with all Programs and Source Code,
   for recording, viewing and scaling ionograms (with readme.txt of 19/9/97) [✓]

All Checked – O.K. [ ]

Signed:– J. E. T

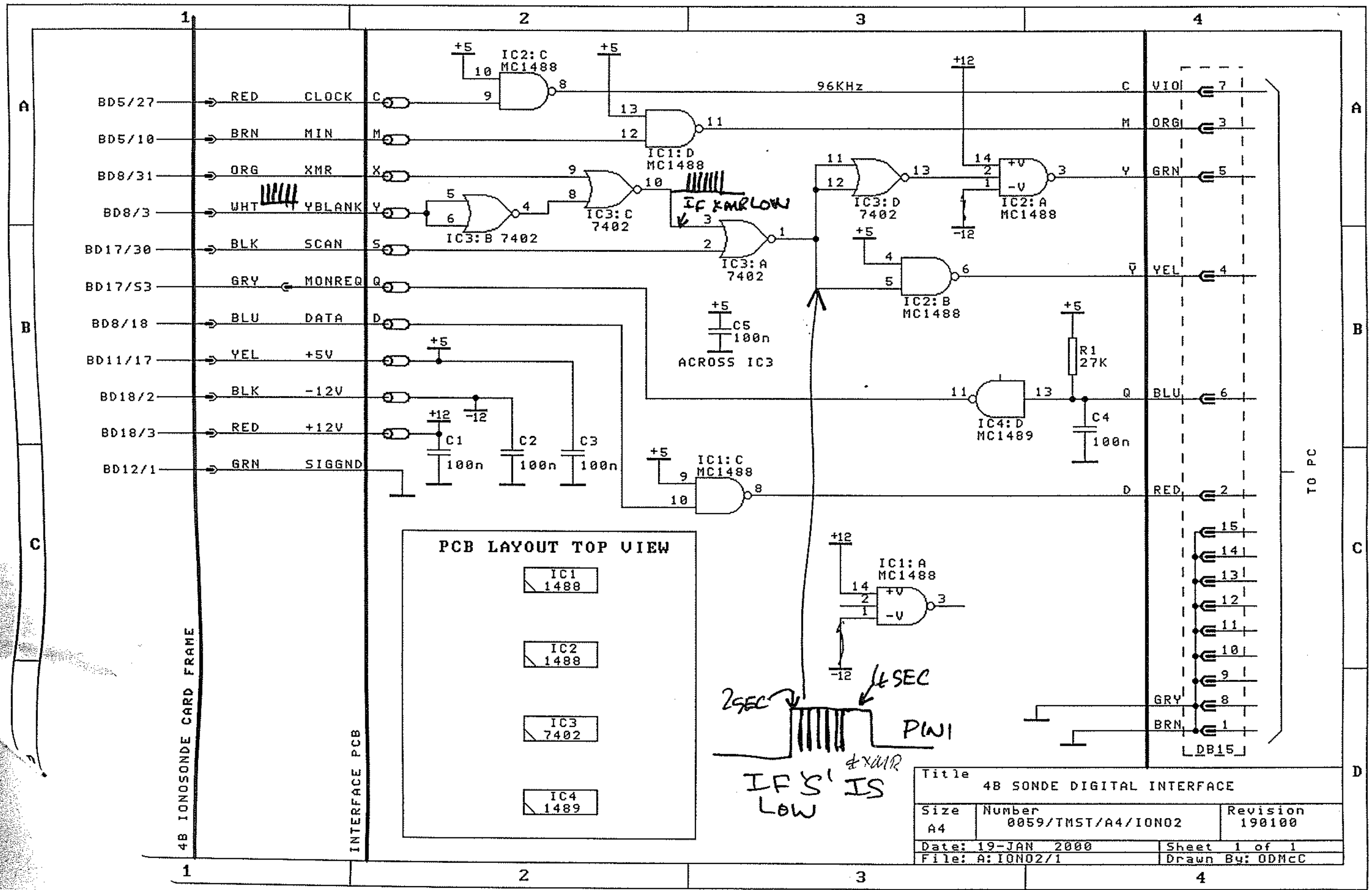
J. E. Titheridge

Date:– 17/12/98


GRN.
YELLOW
BLACK
RED
mc1488N
mc1488N
SN74LS02
mc1489P
BLUE
BROWN
RED
ORG.
BLACK
WHITE.
GRAY

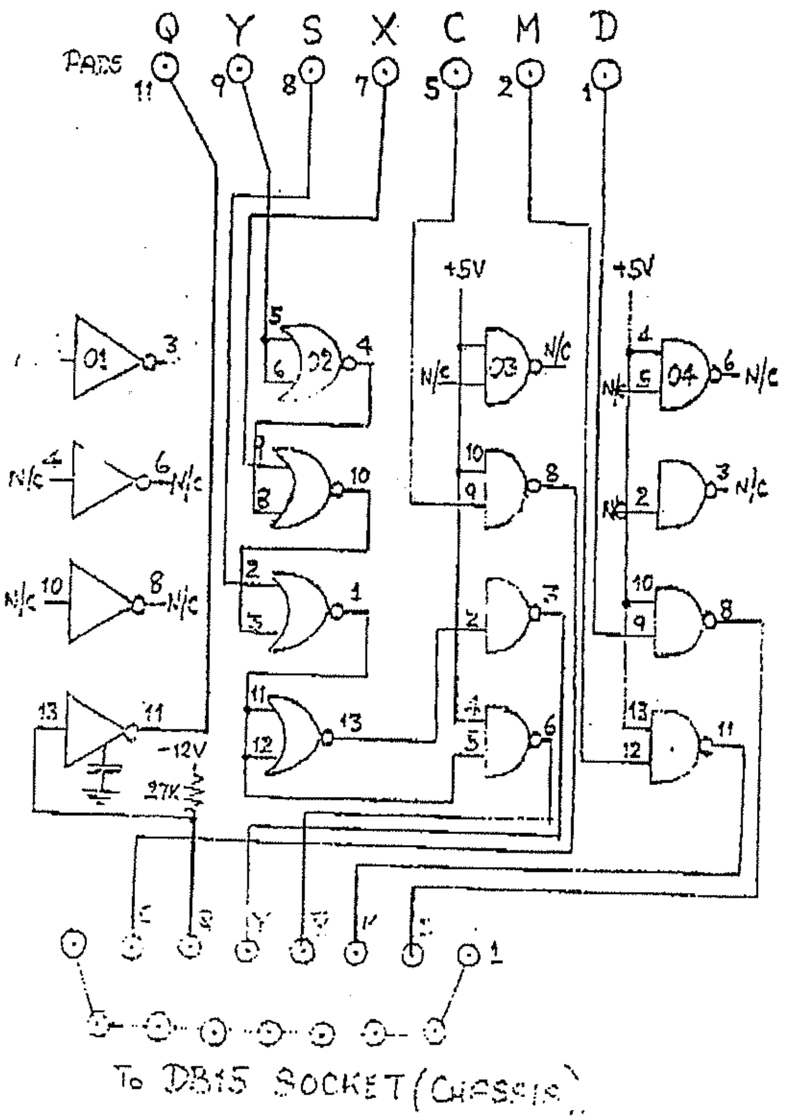
NOT SCANNING XMR 8s 12s

15SEC after min 35SEC after minute etc



APPENDIX 2.

A/L 2/93
SHEET 2 OF

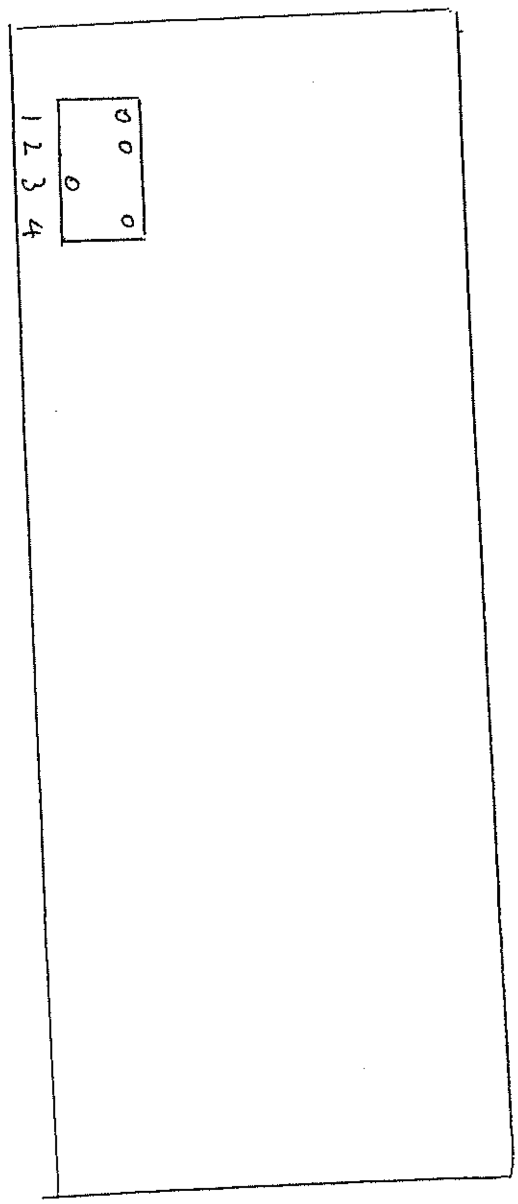


IONOSONDE TO INTERFACE SIGNAL CONNECTIONS.

PAD	DESIGNATION	COLOUR	SIGNAL	DESTINATION.
1	D	BLUE	DATA	BD8 PIN 18
2	M	BROWN	MINUTE	BD5 PIN 10
5	C	RED	CLOCK	BD5 PIN 27
7	X	ORANGE	XMR	BD8 PIN 31
8	S	BLACK	SCAN	BD17 PIN 30
9	Y	WHITE	YB	BD8 PIN 3
11	Q	GREY	ION RQST.	BD17 IC8 PIN 1

IONOSONDE INTERFACE BOARD (RADIO PHYSICS MAY'93)

Toggle switch
setting on
'Sonde board
(maybe)



Yangil and Harry.

Phil is looking for circuit diagrams for the Digeon boards (not the 4D).

Have you seen them or have any idea where they might be?

Bruce