SECTION 3
INSTALLATION, SETTING UP AND FIELD CALIBRATION

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GENERAL WARNINGS

1. **ALTHOUGH THE SOUNDER HAS BEEN DESIGNED FOR RELATIVELY SIMPLE INSTALLATION, THE COMPLETE PROCESS, INCLUDING FIELD CALIBRATION AND GAINING ACCESS TO THE INSIDE OF THE SOUNDER, REQUIRES SPECIAL KNOWLEDGE GAINED BY ATTENDANCE AT A TRAINING COURSE AND INCULCATION OF THE REQUIRED PRACTICAL SKILLS. THEREFORE NO ATTEMPT SHOULD MADE TO INSTALL, CONNECT POWER TO, OR CALIBRATE THE SOUNDER AND ITS ANCILLARY DEVICES BY UNQUALIFIED PERSONS.**
2. **WHEN PACKED FOR SHIPMENT THE SOUNDER WEIGHS APPROXIMATELY 60 KGS. THEREFORE AT ALL TIMES AT LEAST TWO PERSONS MUST LIFT AND CARRY THE EQUIPMENT SAFELY BY THE CASE CARRYING HANDLES.**
3. **NO AUTHORISED INSTALLATION, OPERATION OR MAINTENANCE TASK REQUIRES THE MAIN AND POWER AMPLIFIER CHASSIS TO BE EXTENDED OUT OF THE CASE AT THE SAME TIME. IF BOTH ARE EXTENDED, THE COMBINED MASS OF THE TWO CHASSIS, WILL ALTER THE SOUNDER'S CENTER OF GRAVITY AND WILL CAUSE THE EQUIPMENT TO TOPPLE FORWARD POTENTIALLY CAUSING INJURY TO PEOPLE AND/OR DAMAGE TO CABLES AND OTHER EQUIPMENT.**

GENERAL SOUNDER CONFIGURATION

301. The sounder is provided with a fiberglass field transit case (see Figure 2-1) which is also used to protect the internal components during normal use. During installation, all external connections to the sounder are made with both chassis secured in their normal operating position (i.e., closed) and the rear shipping cover in place. The front cover should normally be left in place during normal operation.

302. Under normal operating conditions, the sounder and most of its ancillary equipment, including a monitor and keyboard, shall be installed in a clean, air-conditioned environment. It will normally be placed on a level table, with no special or fixed mounting requirements being necessary. Desirably, the table shall also serve as a operator's and maintainer's work bench. Its exact position shall be dictated by the proximity to any antenna through-wall feeders specified by the facility design.

303. A single phase double power outlet will be required within approximately 2 m of the table. Where back-up power is required, provision shall be made to fit two sealed lead-acid batteries directly under the table, with allowance to connect the batteries to the sounder by two 2 m cables.

304. Specifications on the sounder hardware are provided in Section 7 and Annex A of the manual.

PRE-INSTALLATION CHECK

305. Prior to installation, place the sounder on a table preferably in the position where it will be permanently operated. Allow at least 40 cm clearance between the rear of the case and any vertical surface to provide access to the rear I/O panel.

306. Remove the front and rear covers and inspect all external fittings for damage. Replace the rear cover before making any cable connections. In turn, release each chassis from the case, remove the chassis cover and inspect for shipping damage. Check for and make good any loose connectors and unseated cards.

ANTENNA INSTALLATION

General Requirements

307. The antenna field consists of one or two transmit antennas (customer furnished equipment), and four receive antenna stations. The installation site requires to be cleared and kept cleared of **all vegetation** within a 0.5 m radius from the antenna and isolated from conductive obstructions by at least a ratio of 10:1 (SEPARATION DISTANCE : LONGEST DIMENSIONS OF THE OBSTRUCTION).

308. Preferably the receive antenna site should be level, however the site may have a uniform gradient of up to 10°. If the site is not level, do not attempt to "flatten" the array by raising individual antennas (i.e., by extending the legs.)

309. The transmit antennas' concrete foundation however must be laid on level ground.

Distance Constraints

CAUTION

BECAUSE OF THE LONG CABLES, INSTALLATION OF THE RECEIVE ANTENNAS AT A DISTANCE MORE THAN 130 METRES FROM THE SOUNDER INCREASES THE EFFECTS OF LIGHTNING.

310. The following spatial distance constraints in the system layout must be adhered to in order to ensure optimum operation:

a. The distance from the center receive antenna station (Antenna # 1) to the sounder should not be more than 100 m.

b. The transmit antenna mast must not be closer than 30 m to the closest receive antenna station, and desirably should not be more than 130 m from the sounder. If required by site constraints, however, the transmit antenna may be installed up to a maximum of 1500 m from the sounder. If this is the case, advice on correct feeder cable selection should be sought from the antenna or cable manufacturer.

Transmit Antenna Interface Requirements

Mechanical

311. The two transmit antenna feeder cables of equal length are connected to the sounder rear I/O panel by N-to-BNC through-wall connectors. According to site facility requirements, in some instances the antenna feeder cables might be terminated at a wall adjacent to the sounder. In this case, equal length, short intermediate cables may be used to connect the sounder to the through-wall connector.

312. Gas-discharge protection devices are fitted in order to reduce the effects of lightning surge upon the sounder and ancillary items.

Electrical

313. The sounder supplies RF energy to the transmit antenna. No HV electrical power is required nor supplied by the system.

Receive Antenna Array Layout

314. The sounder installation uses a receive antenna array consisting of four antenna stations, three of which form an equilateral triangle, the fourth station is located at its centriod. Figure 3-1 details array layout measurements and antenna orientation. The location of each crossed-loop antenna station in each antenna field shall be in accordance with the installation drawings.

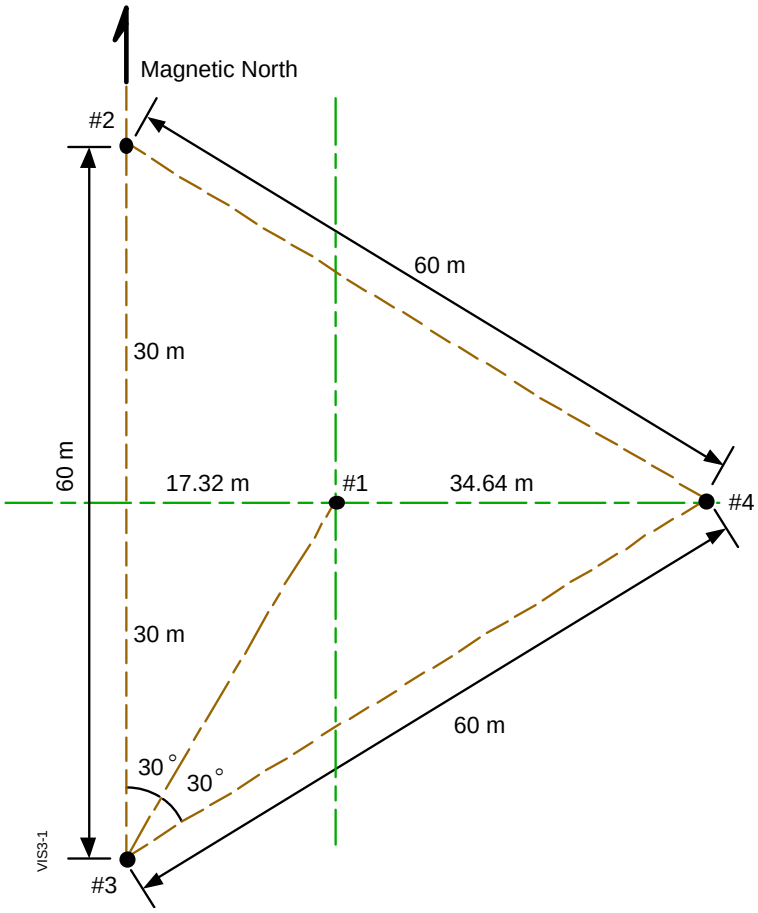

Figure 3-1 Receive Antenna Array Orientation and Spatial Dimensions

315. Each receive antenna station comprises four crossed-loop active elements. Physical details of the antenna station including its concrete footing are provided in Figure 2-4.

316. The vertical plane polarization and East-West (i.e., orientation of North-south loop planes) of all four turnstile antennas must be within ±1° of the datum line. All antenna preamplifier boxes must be oriented identically on each receive antenna station. Orientation of the Antenna #3 / Antenna #2 side of the triangle should be magnetic North. Any deviation from this orientation must be coordinated with the University of Massachusetts Lowell Center for Atmospheric Research, Lowell, MA to incorporate software changes that are required for each deviation.

Antenna Cable Connections

317. Connect each transmit and receive antenna directly to the sounder (or to the facility's wall termination panel) by a length of RG-213/U cable, terminated with a male "N" type connector. The four receive antennas cable lengths must be matched to within 75 mm of each other, similarly with any intermediate cables if used. The recommended cable length to minimise the risk of lightning strike is 130 m, for optimum electrical performance however a maximum length of 153 m may be used. For greater distances consultation with the cable manufacturer is suggested.

318. Connect the two transmit antenna cables to the TX1 and TX2 outputs on the sounder's rear I/O panel.

CAUTION

EACH ANTENNA MUST ONLY BE CONNECTED TO ITS RESPECTIVE REAR I/O PANEL CONNECTOR (E.G., ANTENNA #1 TO CONNECTOR #1)

319. Connect the four receive antenna cables to the respective RX1, RX2, RX3 and RX4 connectors on the rear I/O panel. When installing the receive antenna array and running the cables, verification must be made to confirm that the markings at the sounder end of the cable corresponds to the respective receive antenna location as shown in Figure 3-1.

INSTALLING THE GLOBAL POSITIONING SYSTEM (GPS) RECEIVER

320. The sounder derives absolute time from the external GPS receiver that is part of the sounder subsystem. The current model of GPS receiver is the Trimble Navigation Acutime receiver which is a single self-contained unit, weighing less then 500 g. A 15 m interface cable fitted with a lightning surge suppresser is supplied with the receiver. The receiver is also shipped with a threaded section of pipe and mounting flange.

321. Mount the receiver in an area open to the sky, typically on top of the shelter building, making sure that it is fixed in a vertical position using 6 mm x 25 mm cadmium plated bolts, and with a relatively unobstructed line of sight to the horizon. Connect the receiver to the sounder using the interface cable, with the 7-pin Conxall connector connected to the receiver and the 9-pin sub-D connector connected to the GPS port on the back of the rear I/O panel (see Figure 2-2).

CONNECTING COMPUTER PERIPHERALS

322. All peripheral equipment is connected independently to the electrical power supplied to the site. Refer to the equipment manufacturer's instructions to ensure that proper safety procedures are carried out.

323. The user should connect the monitor to a video output connector (VGA1 or VGA2) and a keyboard to the 5-pin DIN plug as shown in the diagram. If used in a particular application, connect the Okidata 320 to LPT1, and the HP PaintJet to LPT2.

CONNECTING TO THE WIDE AREA NETWORK (WAN)

324. After installing the correct AUI to Ethernet cable adapter (compatible with coax, twisted pair or fiber optic LAN connections) attach the customer supplied terminated WAN cable to the WAN connector on the the adapter.

ELECTRICAL POWER CONNECTION

WARNING

THE POSITION OF ALL HIGH VOLTAGE POWER SWITCHES WHEN POWER IS APPLIED IS IN THE 'UP' POSITION.

CAUTION

AN AC POWER STRIP IS FITTED AS PART OF THE SOUNDER CASE BUT MUST NEVER BE DIRECTLY CONNECTED TO THE MAIN POWER SUPPLY. A STEP-DOWN TRANSFORMER MUST BE USED TO OUTPUT 110 VAC TO THE POWER STRIP. THE POWER SUPPLY AND MONITOR MAY BE RUN FROM 220 VAC POWER IF NOT CONNECTED TO THE 115 VAC POWER STRIP.

External Power Supply

325. To connect external power to the sounder:

a. Make sure that the ON/OFF switches on the power amplifier chassis and the rear I/O panel are both in the OFF (down) position (see Figure 3-2).

b. Ensure that the site mains power at the general purpose power outlet to be used for the sounder is OFF.

c. Connect the battery harness to the 5-pin "BATT IN" socket (see Figure 3-2) and the system battery input cable to the battery input jack. Connect the 3-pin EIA power cable to the "VAC IN" connector on the rear I/O panel.

d. Turn on the power at the general purpose power outlet; the batteries will begin to charge immediately even though the sounder's main power switch is in the off position. Refer to Sections 5 and 7 of this manual for an overview of battery charging and power distribution.

Battery Supply Interface

326. The sounder has an integrated battery interface which prevents the system from drawing current from the batteries unless the two batteries total more than 24 V. If the voltage is too low, this circuit will keep the batteries disconnected until the charging current brings them up to the correct voltage. The illumination of the green LED next to the LCD voltmeter display on the battery interface box indicates that the batteries are connected.

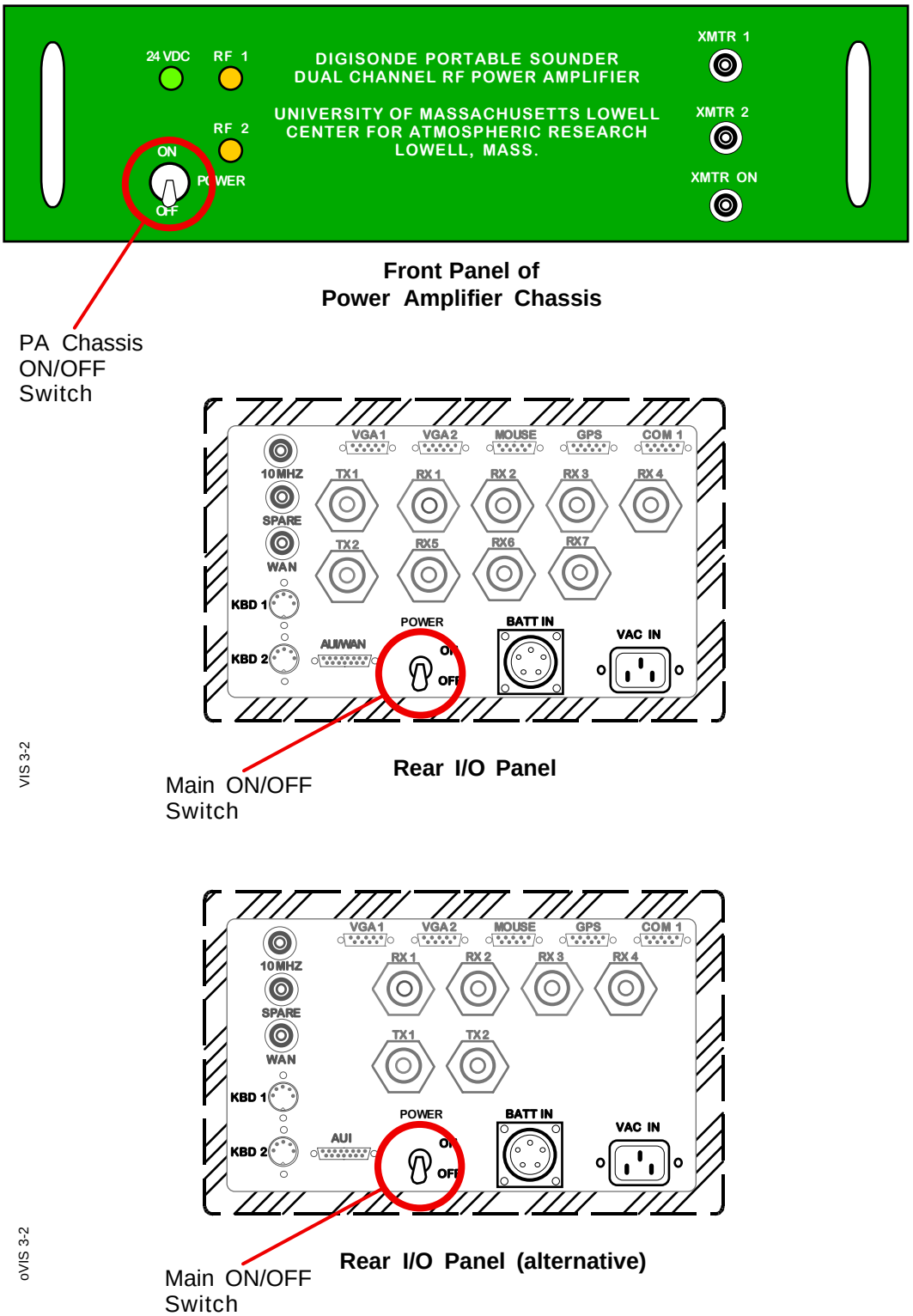

Figure 3-2 Location of Rear Panel Power Switches and Connectors

BOOTING PROCEDURE

327. At this stage the sounder should be correctly connected to the:

a. correct power source, and all power switches in the OFF (down) position,

b. transmit and receive antennas,

c. GPS receiver,

c. external computer monitor and keyboard, and

d. WAN.

328. Switch the ON/OFF switch on the rear I/O panel to ON. This will activate the cooling fans and boot the MAIN and AUX computers. At the completion of the boot-up sequence, which will take over one minute, the control software will be running with the System Status Screen displayed.

INITIALIZING THE GPS RECEIVER

329. During the boot-up sequence, the master system file (DPSCNTL.EXE) will be executed and will attempt to establish a communications path between the sounder and the GPS receiver. When the link has been established, the receiver will return the time-standard, and DPSCNTL.EXE will be able to determine the receiver's status. The GPS receiver interface status values are as follows (as returned by the TIMEX module):

TIMEX (TIMe EXchange) Return Codes

TimexStat return codes (Green):

0 RTC, DOS, IONO TIME SET USING GPS.

1 RESYNC TIMED OUT.

2 GPS NOT CONNECTED. DOS, IONO TIME SET USING RTC INTENTIONALLY.

3 DOS TIME AND SLIPPED RTC TIME ADJUSTED TO IONO TIME.

Problem return codes (Yellow):

4 GPS WAITING FOR ALMANAC TO UPDATE.

5 INVALID TIME SETTING. WILL TRY AGAIN IN 10 SECONDS.

6 CANNOT GET 1-PPS FROM GPS, RTC TIME USED.

7 CANNOT GET 1-PPS FROM GPS, RTC ADJUSTED TO IONO TIME.

10 CANNOT GET PROPER STRINGS FROM GPS, RTC TIME USED.

11 CANNOT GET PROPER STRINGS FROM GPS, RTC ADJUSTED TO IONO TIME.

Fatal exit return codes (Red):

18 CANNOT READ RTC TIME, NO TIME SET.

19 PROBLEM ISSUING GPS COMMAND THROUGH DGSTERM TO PROCESSOR.

21 SPDRIVE NOT LOADED FOR TRIMBLE TSIP.

22 MENU LINE OR COMMAND LINE PROBLEM.

23 PROBLEM WITH DIRECT COMMUNICATION TO PROCESSOR CHASSIS.

Satellite Seek

330. The GPS receiver's satellite seek period could take up to 30 minutes, and during this time it is normal to receive a TimexStat = 4 (in yellow) status condition. Until the end of the seek, the 1-pps signal resync will not be enabled, and the sounder will check on the receiver's status every six minutes, up to 30 minutes.

331. If the receiver still has not found the four satellites required for a good time-lock, the sounder's RTC will be used from that point on; the sounder presuming that the receiver is not fully operational.

GPS Receiver Condition

332. With the GPS receiver installed correctly, and having achieved a lock (at least four satellites in view) within 30 minutes from start-up, the receiver will communicate the time-standard and provide a stable 1-pps signal. This condition will be indicated by the TimexStat = 0 status in green on the System Status Screen, and will enable a re-synchronization of the system 1-pps signal with that of the receiver. After the start-up of DPSCNTL.EXE, the System Status Screen may be brought up automatically or by pressing S. If the receiver's conditions are as expected, the TimexStat line will be green.

333. Using the 1-pps signal from the receiver, re-synchronization of the sounder is done by the TIMEX module. TIMEX will check the receiver's time for stability, then enable the system's re-synchronization, and finally reverify the system versus receiver times for stability. This situation will be signalled by the message:

TimexStat= 0(Synch):RTC, DOS, IONO time set using GPS in green.

RTC Condition

334. When the receiver is disabled intentionally by the operator, the sounder's RTC will be used as the time-standard. This condition will create a TimexStat = 2 message which will be displayed in green on the System Status Screen.

335. Occasionally when TIMEX is not able to tell the main system software that a re-synchronization to the 1-pps signal is to be called, a time-out within TIMEX will occur. Upon re-entry, re-synchronization will be enabled, and will be displayed on the System Status Screen as:

TimexStat=2(post-synch):GPS not connected DOS, IONO time set using RTC intentionally also in green.

336. If there is no 1-pps signal at the rear I/O panel, the sounder may attempt re-synchronization, but since the timing card has a pull-up resistor on that line and the card looks for a falling-edge transition, the position of the 1-pps signal will remain unchanged. This allows for the system to synchronize once, then be disconnected from the 1-pps signal and remain in synchronization.

CONFIGURATION MANAGEMENT OF SITE-SPECIFIC DATA

337. Each sounder is pre-configured for its destination site prior to shipment. However, site-specific data may need to be adjusted in case of relocation, changes to instrument configuration, or availability of more precise site-specific data.

338. The following ID tags are assigned to each sounder:

STATION ID. A unique 3-digit number that is used to label all data products. REQUIRED. Post-analysis software reads the Station ID from the data records to identify location at which they were acquired and the sounder configuration. The Station ID shall be changed if the sounder is relocated, unless its operations imply constant relocation. Changes to Station ID shall be coordinated with UMLCAR where a repository of Station IDs is maintained to avoid conflicts with existing IDs. It is possible to keep history of minor configuration changes without changing the Station ID. For example, it is possible to reflect upgrades to the sounder's hardware and antenna array pattern and retain the same Station ID.

URSI CODE. A unique 5-character code given by the URSI to observatories. REQUIRED. The URSI code is associated with the location of the sounder, not its model or hardware configuration. The URSI Code is written in the SAO records holding ionogram-derived data to be reported to the WDC and other users.

SERIAL NUMBER. A unique number given to each DPS sounder made by UMLCAR, in the sequence of their production. PROVIDED BY UMLCAR. Serial number is only displayed on the sounder's homepage and not stored with the data.

WMO ID. Sequence of three codes identifying the sounder location for the World Meteorological Organization. OPTIONAL.

339. Site-specific information can be found in the text files holding software configuration data. Table 3-1 enlists the configuration files.

Table 3-1 Software Configuration Files holding site-specific data

FILENAME	LOCATION	GENERAL DESCRIPTION
ARMENU.DPS	D:\DPSMAIN\DPSOPER\	Defines the Station ID for the sounder, stores station constants for the ARTIST and DPSCntl software
xxx.UDD (xxx = Station ID)	D:\DISPATCH\UDD\	Station UDD file. Provides station constants for post-processing and visualization software. Stores records of changes to ensure that retrospective data are processed correctly. Station ID files are kept at UMLCAR under version control management and distributed together with the analysis software to other users of digisonde data
DDASETUP.ONL	D:\DISPATCH\	Provides station constants for the DDA, DDAV, and DDAS software
DISPATCH.UDD	D:\DISPATCH\	Stores time zone specifics and text of labels for the web scripts supporting home-page operations of the sounder

Description of Antenna Configurations

340. Knowledge of antenna array configuration is required for interpretation of digital beamforming results obtained by DPSCntl for the RSF ionograms, and for all software that processes drift data. Whereas drift data records contain complete unprocessed four channels of data, multi-beam ionogram files hold processed results.

341. Antenna array specifications are made in the system of coordinates where X points to the Compass North, Z is the local vertical pointing up, and Y forms the right-hand system (i.e., points to the West). Figure 3-3 shows three common DPS-4 antenna configurations, (1) Standard per manual, (2) Mirrored (rotated 180° about the X axis), and (3) Rotated (rotated 180° about the Z axis).

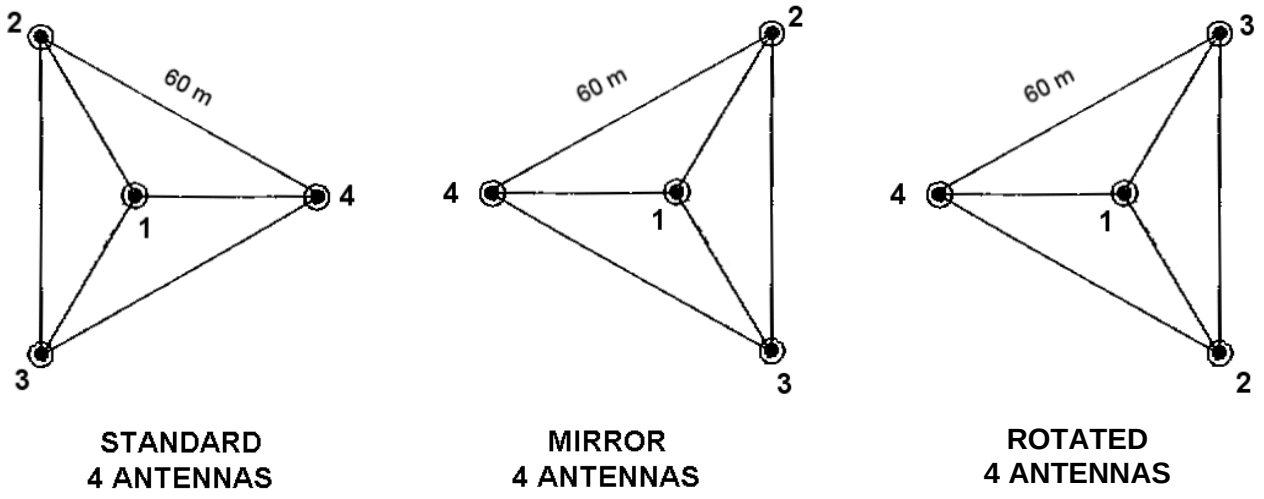

Figure 3-3 Three common DPS antenna configurations

342. Early versions of DPSCntl software used to perform digital beamforming assuming antenna configuration to be "standard per manual", regardless of the actual configuration. Responsibility of correct interpretation of directions in the multi-beam ionograms is placed on the visualization software (ADEP, Viewer, SAO Explorer, Ion2PNG). Visualization software can be configured to correctly label directions in RSF ionograms for the three common antenna configurations shown in Figure 3-3.

343. If antenna configuration does not fall in any of the three common categories, DPSCntl must be configured to modify its beamforming coefficients so that the resulting beam numbers correspond to the "standard per manual" antenna layout. When visualization software interprets ionogram data for locations with uncommon antenna configurations, it treats them as the standard-per-manual.

344. For drift analysis, both DDA and Drift Explorer use a more generic scheme for antenna array specification, where both antenna pattern and antenna orientation can deviate from the commonly used patterns. Figure 3-4 illustrates the concept of the flexible antenna specification. Complete specification of antenna array for DDA/DE analysis includes four components,

1. ANTENNA LAYOUT, which can be
    a. STANDARD (counting antenna numbers counter-clockwise), as in Figure 3-3,
    b. MIRROR (counting antenna numbers clockwise), as in Figure 3-3, or
    c. NON-STANDARD.
2. DEVN, angle between Compass North and the line connecting antenna 3 and 1, counted counterclockwise from Compass North to "3-1" line, taking values from –180 to 180 degrees.
3. MAXDIST, maximum distance between antennas in meters.
4. TABLE OF ANTENNA COORDINATES, which is required for locations with NON-STANDARD antenna layout.

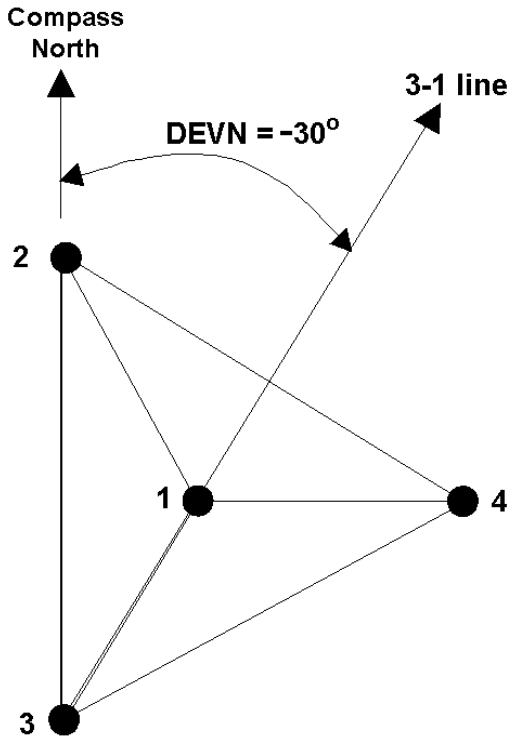

Figure 3-4 Specification of the DEVN parameter for antenna configurations

345. Complete antenna specification for both ionogram and drift data interpretations is available in the Station UDD file, xxx.UDD, that contains all five entries for antenna specification:

1. ANTENNA PATTERN (for ionogram analysis)
2. ANTENNA LAYOUT
3. DEVN
4. MAXDIST, and
5. TABLE OF ANTENNA COORDINATES

ARMENU.DPS file stores only ANTENNA PATTERN, and DDASETUP.ONL stores all elements of description except ANTENNA PATTERN.

346. Table 3-2 summarizes all station-specific configuration items that need to be personalized for the sounder.

Table 3-2: Site-specific configuration items to personalize for DPS

FILENAME	ITEM #	CONTENTS	SOFTWARE COMPONENT
ARMENU.DPS	942	Station ID	DPSCntl: tagging SBF, RSF, DFT data
	945	System model	DPSCntl: configures multi-beam analysis
	946	Restricted frequencies	DPSCntl: blocks transmission on restricted frequencies

FILENAME	ITEM #	CONTENTS	SOFTWARE COMPONENT
	950	System configuration	DPSCntl: enables component-specific algorithms
	082	Noise environment	DPSCntl: adjusts front gains for noisy environments
	101	Geographic latitude	ARTIST: tagging SAO data
	102	Geographic longitude	
	104	Gyrofrequency	
	105	Dip angle	
	032	System model	
	307	URSI ID	
	301-303, 306, 308	WMO IDs	ARTIST: for optional reports to WMO
	011	Sunspot number	ARTIST: use of item 011 is discontinued
	086	Rx antenna layout	ARTIST: for internal use
xxx.UDD	304	Station name	Online image tools : display
	101	Geographic latitude	
	102	Geographic longitude	
	104	Gyrofrequency	
	105	Dip angle	
	106	Magnetic declination	
	307	URSI Code	
	032	Digisonde model	Online image tools: data reading and display
	086	Antenna pattern	Online image tools: display DrgMaker: generation of directograms
	090-092	Antenna layout, DEVN, MAXDIST	To be used by new drift analysis tools
	080-082	Antenna coordinates	
DISPATCH.UDD	055	URSI Code	Dispatcher: filename generation
	130	Display title	Web scripts: display
	133-137	Local time and daylight savings	Web scripts: display
DDASETUP.ONL	185	Station constants	DDA : data analysis
	184, 170, 177	Antenna coordinates	

RESTRICTED FREQUENCIES

347. Refer to the frequency authorization operating license obtained for the sounder at the installation site and note any frequencies to be protected. Then following the procedures in Section 6 enter the lower end and upper end of each frequency to be avoided during transmission.

POWERING ON THE RF AMPLIFIER AND ANTENNA SUB-SYSTEM

CAUTION

THE TRANSMIT ANTENNAS MUST BE CONNECTED TO THE SOUNDER PRIOR TO APPLYING POWER

348. To power on the RF amplifier, simply turn the power switch on the front panel of the Power Amplifier Switch to ON.

NOTE

The power switch on the Power Amplifier Chassis front panel energizes the power amplifier ONLY, not the entire system.

FIELD CALIBRATION

CAUTION

AT ANY TIME DO NOT PATCH TX1 OR TX2 DIRECTLY INTO ANY OF THE RX CONNECTORS ON THE REAR I/O PANEL TO SET UP A LOOPBACK. THE RX CONNECTORS HAVE 24 VDC ON THEM TO POWER THE RECEIVE ANTENNAS.

TO CONNECT AN EXTERNAL LOOPBACK, BLOCKING CAPACITORS MUST BE CONNECTED IN SERIES WITH THE ANTENNA SWITCH INPUTS AT THE REAR OF THE MAIN CHASSIS.

349. Although the sounder is subjected to detailed calibration and testing during manufacture and prior to shipping, final calibration must be completed in the sounder's ultimate operating environment to ensure that the sounder and antenna sub-systems are correctly matched and deliver optimum performance. Field calibration involves:

a. Matching the antenna cable lengths,

b. Adjustments to the cable lengths for varying antenna heights,

c. Detecting defective cables and Antenna Pre-amps,

d. Verifying the correct directions in both Ionogram and Drift modes of operation.

Preliminary Requirements

350. Field calibration shall only be performed by personal who have qualified on an authorised Digisonde™ Sounder training course, and who have access to the relevant calibration equipment specified in this section. Proficiency in sounder operations as described in Section 4 of this manual is mandatory.

351. Before any field calibration is performed the sounder and antenna sub-systems must be installed as per the preceding instructions. In particular, the transmit antenna(s) or dummy load must be connected.

Installation of Dummy Load

352. A dummy load can be placed on the system by looping back the TX1 or TX2 output from the main chassis front panel through a 40 to 100 dB attenuator and inject the sounder's transmission directly into the receiver card using the BNC to SMC receiver input cable connected between the antenna switch and the receiver card. Software Calibration Program E (described in Section 4) includes the correct default parameters to set up this procedure.

Transmitter/Receiver Signal Coupling

353. There is enough coupling of the transmitter signal onto the receiver input cable to require no physical connection provided if G = 3 or lower (high gain) is set in the program. The First Height parameter in Program E must be set to 0 km for a successful loopback test. A loopback test through the antenna switch box can be made by selecting DISK_IO parameter (#16) equal to C. This activates an internal loopback switch to apply the CAL RF output of the XMT card.

354. The power amplifier can be operated with only one input signal without damaging it. Provided that the active output is properly loaded (with either a 50 W load or an antenna) the inactive output does not need to be loaded. The higher input BNC (XMTR1) on the front panel of the Power Amplifier chassis is electrically identical to higher output N-type connector (RF1) on the rear of that chassis. **DOUBLE CHECK** that the correct output is connected to the antenna or dummy load.

Internal Phase Calibration of Sounder (excluding antennas and cables)

355. Periodically running a Calibration Ionogram (Disk Parameter = C) calibrates the phase variation in the Receiver and Tuner Cards of the 4-channel DPS-4 sounder. This calibration ionogram is usually the E Program. The Phase calibration is saved in the RCVRCAL0.DFT file. This file automatically corrects phase differences in the four receivers for all subsequent Ionograms and Drift.

356. An automatic calibration procedure is activated by setting the disk I/O parameter, D, (#16 in the program menu (see Section 4)), equal to "C". This selection does three things:

a. Switches the XMT card output through an attenuator (on the XMT card) and injects it directly into the antenna switch assembly (via the coaxial cable labelled "Cal In").

b. Disables the RF power amplifier by gating off the XMTR pulse signal (accessible on the front panel) which normally activates the bias voltage of the RF power FET.

c. Switches the antenna switch inputs from the four external antennas to the directly injected transmitter signal.

357. The program settings below (Table 3-3) will result in a new file RCVRCAL0.DFT, being written into the D:\DPSOPER directory. From that point on, whenever a program is initialized, the new phase and amplitude correction factors will be applied. After this procedure is run, the 4-channel sounder can then check cable lengths and the phase response of the loop antenna pre-amplifiers in the same way as the single channel sounder, described previously.

Verification of Phase Measurements in External Loopback (4-Channel Sounder Only)

358. To verify the phase accuracy of the four receiver channels, a known phase difference can be created by using a set of four BNC cables each 1, 1, 3 and 7 m long. Using the loopback configuration with the series capacitors as described for the alternate internal calibration, place the 3 m cable in the antenna #1 loopback channel and the other three in any order. This simulates off-vertical signal reception at about 8.5°. Using the beamforming program with parameter 9 (first height sampled) = 0 km, the angle shown should be overhead (Magenta coloured echo spots). However, by editing the setup menu (see Section 6, EDITMENU.BAT) and chang-

ing the zenith angle (the first parameter) to 10° any subsequent beamforming runs will show the looped back signal as arriving obliquely. Remember to return the zenith angle setting to 30°.

NOTE

Setting the zenith angle of the azimuthal beams to 10° means that any angle of arrival greater than 5° will favour this beam rather than the overhead beam.

Matching antenna cable lengths

359. Ideally all the antenna cables should be matched to 6 inches or 20 cm. They can be matched using either physical or electrical techniques. To match physically layout cables on flat, smooth surface such as a driveway. To match electrically, use a Time Domain Reflectometer (TDR). Or there is a technique using a Frequency Synthesizer and Oscilloscope. The far ends of the cables should either all be either open or shorted.

Table 3-3 Internal Calibration Program Parameters (Default Program E)

: (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)	0	: (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.

Over the Frequency range of 2 MHz to 10 MHz measure the average Δf between R. F. voltage nulls to 1 KHz resolution.

L (meters) ~ 100 / Δf (MHz)

Rx antennas not on level terrain

360. It is preferable to keep antennas approximately same distance above the ground to keep effect of ground reflections on the antennas the same. Add short cables of

Length = 0.66 x height difference (with respect to lowest antenna)

to each higher antenna cable.

Field calibration of antennas and cables

361. With a quiet Ionosphere, Ionograms with directions should generally appear to be overhead. Skymaps from Drift should appear to be overhead, also. Figure 3-5 is a sample of the skymap showing ionospheric tilt close to 0.

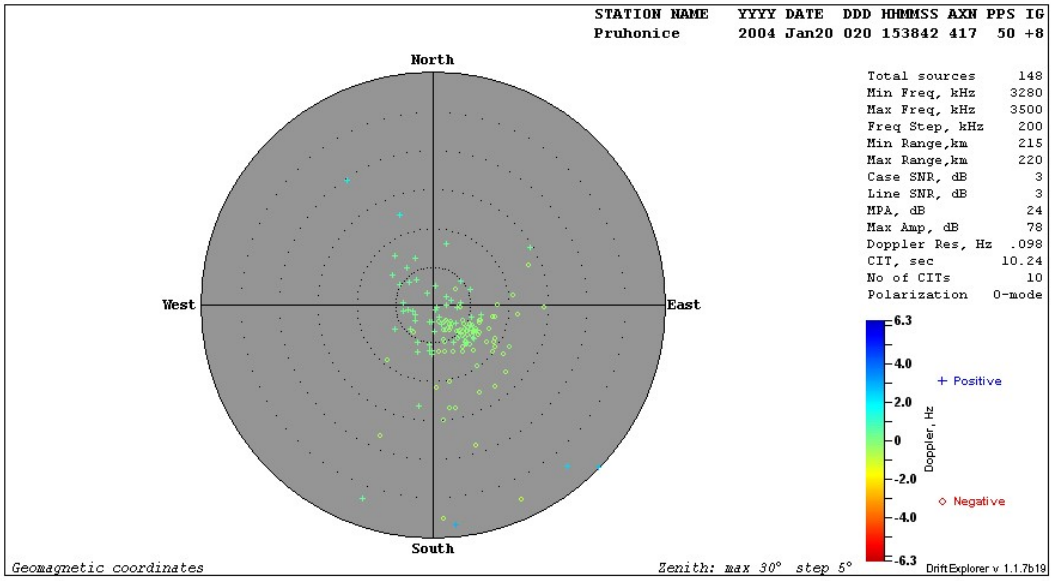

Figure 3-5: Almost overhead ionosphere - No test cables inserted

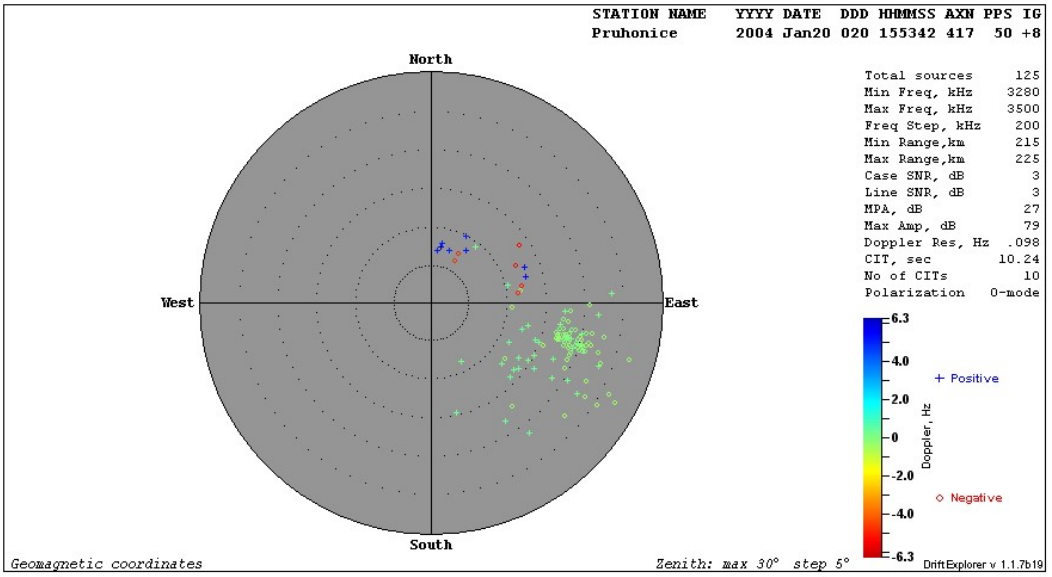

Figure 3-6: Apparent echoes shifted 10 degrees East with test cables inserted on West and Center antennas

362. After verifying that the Ionograms and Skymaps generally appear to be overhead, add two test cables to artificially tilt antenna array as follows. For a four antenna array, 60 meters on a side, temporarily add a 6 meter extension to an outer antenna cable and temporarily add a 2 meter extension to the center antenna cable. This will tilt the antenna beam approximately 10 degrees in the direction away from outer antenna which has the extra cable length (see Figure 3-6 and Figure 3-7).

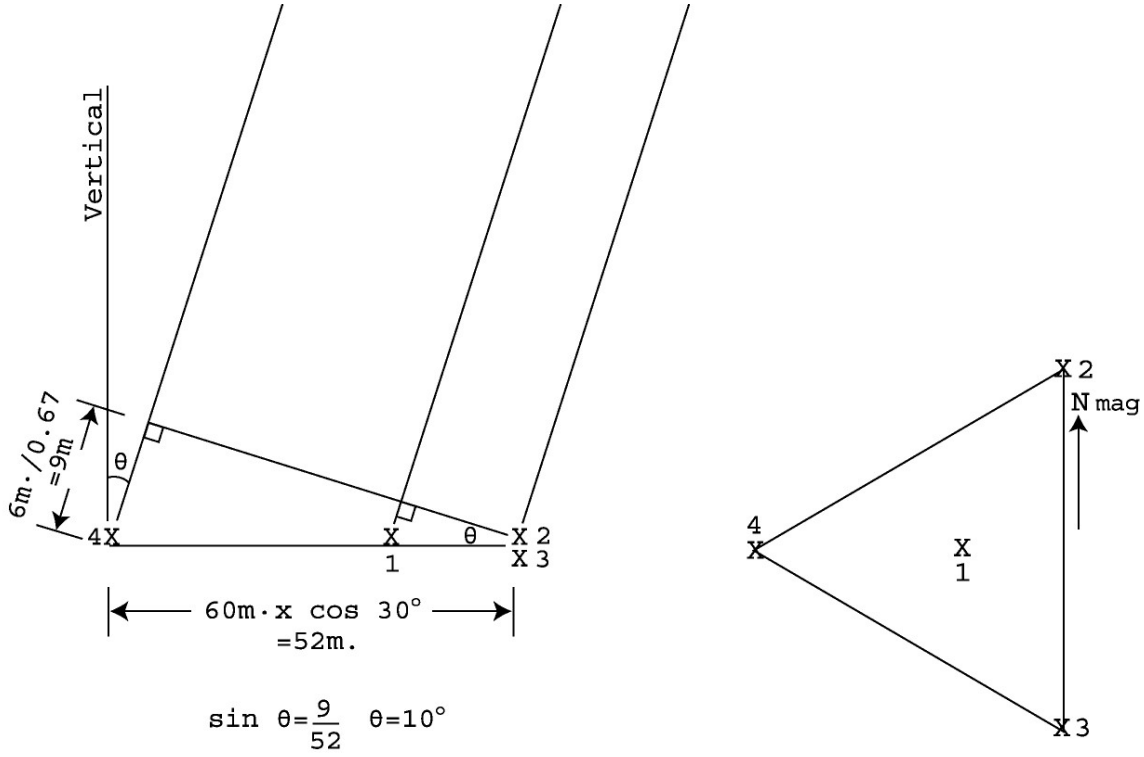

Figure 3-7: Rx Antenna Calibration setup with added test cable segments

External Calibration

363. Since phase angle errors in the measurement of signal echoes at each of the four receive antennas will cause an error in the angle of arrival measurements made by the sounder, the following calibration procedure shall be used to measure and correct these errors. This procedure must be performed at system installation, and may be checked periodically with an automated test to see if a full calibration is necessary.

NOTE

The 4-channel receiver variant of the sounder must be internally calibrated before being used to measure cable and antenna phase delays (see paragraphs 344-346 above).

364. If a 4-channel receiver model is in use and after calibrating it internally (see the Program E menu parameters in Section 4) change the disk format parameter from C to D (see External Calibration program menu) in Table 3-3 below. The physical configuration for the external calibration is shown in Figure 3-7.

Table 3-3 External Calibration (or Alternate Internal) Calibration Program

: (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.

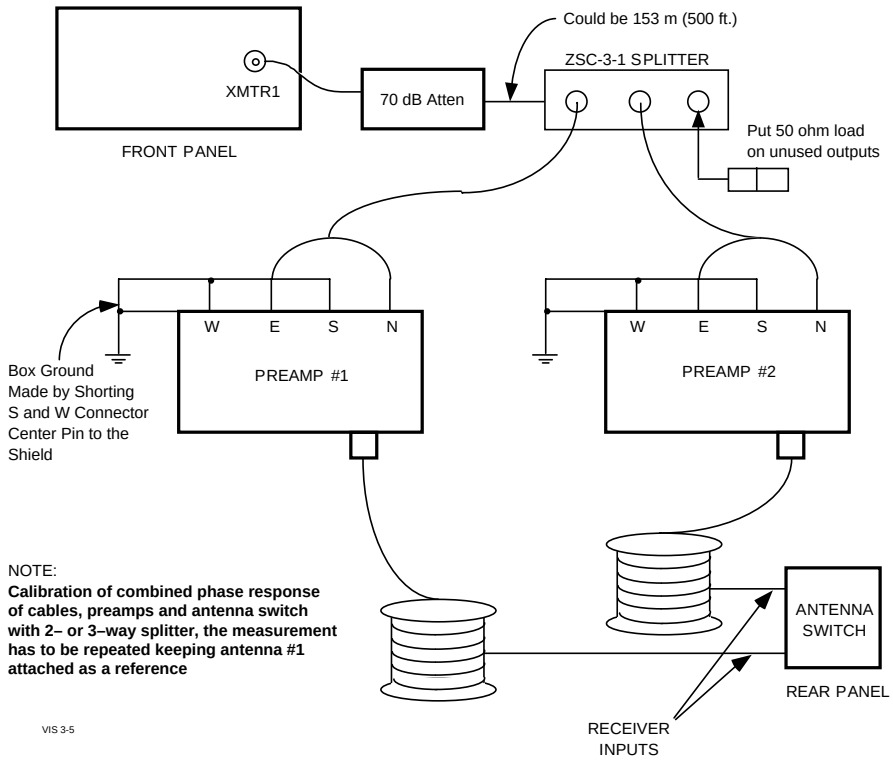

Figure 3-7: Calibration of Combined Phase Response of Cables, Preamplifiers and Antenna Switch

365. Set the program parameters as shown in Table 3-3 and make a scanning drift ionogram (NOTE: This mode stores the entire complex spectrum independently for each antenna at each sample height) over the range of frequencies for which a calibration is desired (e.g. 1000 to 16,000 kHz). Using fine steps of 100 kHz separation and recording 1 height (the O), perform a loopback test of the system and an end-to-end calibration of the phase and amplitude response for each antenna as a function of frequency.

366. Ideally, use a 4-way power splitter to feed all antenna pre-amp boxes simultaneously thus saving the tedium of comparing two antennas at a time (three times). The program SHOWDFT.EXE (which can be run from the "UTIL" menu on the main computer's display screen), as described in Section 6, can be used to read the amplitudes and phases on each antenna as recorded in the resulting DFT, or drift file.

367. For field calibration of the receive antennas, it is recommended that a length of RG-58 cable be available of sufficient length to reach from the furthest receive antenna to the sounder. This cable should be terminated with BNC connectors.

368. The phase errors (difference in measured phase angles from four in-phase source signals) in antenna response (not necessarily between receivers in a 4-channel system) should be less than 5° even without calibrated correction, so if these procedures show errors in excess of 5°, inspect the magnetic loop antennas for reversed cable connections or breaks.

369. If the connections are correct and the phase difference persists, the pre-amplifier boxes should be swapped between the antennas showing a large phase difference, and the test re-run to see if the phase difference is now the negative of what it was (indicating a problem in a pre-amplifier).

370. If errors still exceed 10°, the coaxial cable connections to the antenna switch should be swapped (e.g., connect antenna #1 to the antenna #2 input) and re-run the test to see if the inverse phase error occurs (indicating a cable length error). At this point the electronics have been eliminated as the cause of the problem, so if errors still exceed 10° the antenna cable lengths should be adjusted or the "bad" cable replaced.

Alternate Internal Calibration

371. An alternative means of calibrating the four receivers is to loopback the XMTR1 signal through a power splitter and isolation capacitors directly into the antenna switch (a 0.1 μF series capacitor is required in each receiver cable since the antenna switch supplies a DC voltage to the pre-amplifiers). This amounts to replacing the pre-amplifiers in Figure 3-3 by series capacitors. The external calibration program shown previously should be used with this configuration.

372. Before running this program delete or rename the existing RCVRCAL0.DFT file in D:\DPSOPER. This program will not produce a RCVRCAL0.DFT file on the hard disk. When a good calibration is obtained, copy the DATETIME.DFT file from the RAM drive, E:\ARCHTAPE, to the hard disk, D:\DPSOPER\RCVRCAL0.DFT. If the RCVRCAL0.DFT file is not deleted first the phases shown by SHOWDFT.EXE will all be nearly zero and the amplitudes will be equal due to the action of the previous internal calibration previously performed. Therefore the new "calibration" file would not contain the actual phase and amplitude differences as caused by the analog receivers.

Radiative Calibration Checks

373. Radiative calibration is to be used to check on changes in the magnetic loop receiving antennas or cables. Using a valid calibration file (i.e., don't delete the RCVRCAL0.DFT file), enter the settings for the external calibration program, with G (parameter 13) = 7. Disconnect the loopback cables and capacitor box and reconfigure the system for normal operation, including transmitting from the normal transmitter antennas.

374. Run the program and copy the resulting file from E:\ARCHTAPE to D:\ARCHTAPE\CAL for future reference (the E: drive is a RAM drive in memory and is only used for temporary storage). A follow-up measurement can be made at a later date, and SHOWDFT.EXE can be used to analyze any phase or amplitude differences which may have occurred in the system. If differences are unacceptable (>5° or >3 dB), an external calibration should be done (as described in Paragraph 334 et seq above).

POST INSTALLATION CHECKS

375. At this stage it is recommended that the operator tests the system by modifying and running measurement programs as outlined in Section 4 (Operating Modes and Instructions) of this manual.