Inverted Echo Sounder
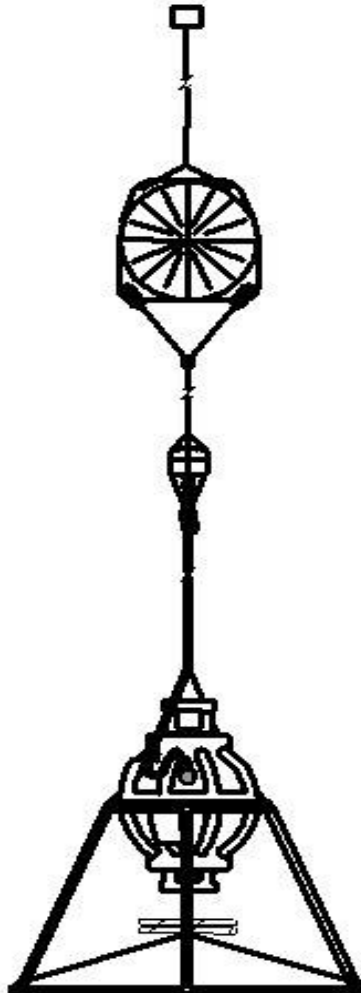# User's Manual

IES Model 6.2

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Table of Contents

Chapter 1   IES Model 6.2 OVERVIEW

The Inverted Echo Sounder (IES) is an ocean bottom-moored instrument that measures the vertical acoustic travel time (VATT) round-trip from the sea floor to the sea surface and back. The URI-GSO Model 6.2 is a combined IES, data-logger, and acoustic release, with optional measurements of bottom pressure, temperature and current speed and direction (with attached Aanderaa™ Doppler current sensor). Data are processed in situ and are available (optional) remotely by an acoustic telemetry link or expendable, satellite-link data shuttle.

The VATT varies principally due to changes in the integrated temperature profile of the water column. Applications in several large and meso scale ocean currents and frontal zones have demonstrated that VATT can often be re-interpreted as geopotential height (dynamic height), which varies due to current meandering and eddies. Thus, the IES is well-suited to monitor changes in temperature structure and dynamic height. In many regions the vertical profiles of temperature and geopotential height, which vary with time, may be determined from VATT measurements. Data from laterally separated IESs can then estimate horizontal gradients in geopotential height, from which geostrophic ocean current profiles may be calculated.

In addition to the largely baroclinic IES-measured VATT, barotropic near-bottom pressure variations may be measured with an optional pressure sensor. The Paroscientific Digiquartz sensor is used to achieve the desired accuracy and long-term stability, and for consistency with this purpose, a super-stable temperature-calibrated time base is added. The Digiquartz sensor also measures the near-bottom temperature; this is used to correct for the slight temperature sensitivity of both the pressure sensor and the IES time base.

Our engineering/research group has been directly involved in more than 25 years of development and field experience with IESs at Yale and Columbia Universities, Woods Hole Oceanographic Institution (WHOI), and the University of Rhode Island (URI). The new Model 6.2 IES retains a measurement system, based on a beamed acoustic transducer and our echo-detector with a proven track-record. The controller/data-logger (Persistor™ CF1 computer module) incorporates the simplicity and reliability of microprocessor control and solid-state ("flash-memory") data storage, plus improved time-base, data-processing and telemetering capabities… features not available on earlier versions.

1.1 INSTRUMENT FEATURES

- Entirely self-contained in a single, non-corroding, glass sphere: acoustic & timed release, flotation buoyancy and optional recovery aids (radio or GPS beacon, xenon flasher and flag)
- 32-bit microcontroller combines high-performance data manipulation (tidal signal filtering of VATT and pressure data) with low-power operation modes
- data stored on removable (type ATA compact flash) memory cards (16 - 512Mbyte capacity)
- data stored as engineering units in MS-DOS file formats
- many self-test features
- through-the-glass communications – high speed data download without opening housing
- acoustic command subsystem, including acoustic telemetry option
- acoustic command and data logging circuitry and batteries are independent
- 17-inch (43 cm) diameter glass sphere instrument housing provides buoyancy for 120 to 240 Amp-hr Lithium battery. Typical deployment durations of 2 – 5 years, depending on measurement schedule, water depth (output power), sensors installed, and battery capacity.
- pressure/temperature measurement as well as current speed/direction options
- long-term stability and barotropic pressure resolution better than $10\mu Pa = 0.1$ mbar (equivalent to 0.001 m water)

Web-page: http://calvin.gso.uri.edu/
(includes photos, project descriptions, and link to IES bibliography)

1.2 OPTIONAL MODIFICATIONS

At this printing (1/1/2005), the available options are:
- Pressure sensor, for measurement of absolute bottom pressure
- Aanderaa™ model 3820R acoustic Doppler current sensor – single point, up to 50 meters above the moored IES

1.3 STANDARD ACCESSORIES

The following accessories (with URI-GSO part numbers) are standard and are provided with each instrument or group of instruments:
- Recovery flag   P/N 13-07
- Polypropylene recovery line   P/N 11-08
- Spare release block   P/N 12-05
- Spare mechanical parts kit,   P/N 10-05 (see Appendix F)
  ➢ nylon hardware: 3/8"-16 x 1.25" bolts with washers and nuts (2)
  ➢ nylon hardware: 3/8"-16 x 2.00" release block mount bolt (1)
  ➢ anchor line: 5/16" Dacron (2)
  ➢ plastic cable ties (6)
- Internal communications cable (6ft)   P/N 54-11 (2 each for each group shipment)
- External communications cable (6 ft)   P/N 51-05 (2 each for each group shipment)
- IES User Software Disk   P/N 59-01
- IES Model 6.2 User Manual   P/N 58-01
- Glass sphere sealing materials kit   P/N 11-12 (see Appendix F)
- Calibration documents for pressure and temperature sensor   P/N 58-02
- Calibration document for IES time base   P/N 58-03

1.4 REFURBISHING KITS AND SPARE PARTS

Some IES parts are used up during routine deployments (battery, sealing tape, release block anode, anchor and line), while others need to be replaced when they show deterioration, e.g., release block cathode, rubber cables, o-rings, plastic parts. Appendix F, at the end of this manual, lists maintenance kits, special assemblies and spare parts available from URI-GSO. Equivalent second source part numbers are stated where applicable. Contact URI-GSO for pricing and delivery schedule.

1.5 IES Model 6.2 SPECIFICATIONS

General _____

measured parameters	acoustic travel time; bottom pressure & temperature (optional)
data storage	type ATA compact flash card
data capacity	32 Mbytes standard (opt. 32-192 Mbytes) – removable memory card
data playback	memory card adapts to type ATA card reader – or RS-232 download
data format	MS-DOS file formats – data in physical units
communications	RS-232, fixed at 9600 baud, 8 bits, 1 stop, no parity
measurement rate	menu-selectable burst-sampling at 10 minutes to 1 hour interval
battery capacity/life	120 Amp-hrs standard; optional 180 and 240 Amp-hrs
	Lithium battery pack (2–5 year deployment – depends on measurement schedule, options added and water depth)

Acoustic Travel Time_____

pings/measurement	24 pings/hour, in programmable bursts of 4, 8, 12, or 24 pings each
ping interval	alternating 16 & 18 seconds to avoid aliasing by surface waves
ping duration	6 millisecond
ping frequency	12.0 kHz (for reception on standard shipboard depth recorders)
operating depth	500 to 6700 meters
acoustic transducer	custom transducer with conical radiation beam
bandwidth (-3dB)	150Hz centered at 12kHz
acoustic output power (standard)	adjusted under firmware control for depth: 170 – 197 dB re 1uPa
echo detection	multi-stage, hard-limiting receiver followed by broad & narrow band filters (150 Hz bandwidth)
echo time resolution	0.01 millisecond each ping
measurement "noise"	(std deviation of 24-ping median) typically < 0.5 ms in 4500-m deployment @ 25-kt wind; < 1.5ms in rain
acoustic telemetry	pulse delay telemetry (PDT) of average travel time after each measurement burst

Pressure (optional)_____

sensor	Paroscientific Digiquartz model 410K (optionally 46K, 42K)
FS range (standard)	10000psi (6000dbar)
FS range (options)	6000psi (4000dbar) or 2000psi (1300dbar)
freq-counter time-base	added to PIES with compatible accuracy, low-drift, and temperature calibration
resolution	0.001 dbar (1mm H_2O) for 4000 dbar sensor (1 part in 64×10^6)
absolute accuracy	+/- 0.01% FS
drift	4 ppm/month
temperature compensation	coefficients provided with each sensor

Temperature (optional)_____

sensor	Paroscientific Digiquartz, temperature included in Pressure option
FS range	0 – 125°C
resolution	0.1 millidegree (1 part in 12×10^6)

Current Speed & Direction (optional)_____
 see Manual Section 12.2

1.5   IES Model 6.2 SPECIFICATIONS (cont'd)

Power System_____

system battery	Lithium DD cells, up to 8 parallel stacks of 2 cells; 240 Amp-hours @ 7.4Vdc (17-inch sphere)
release battery	Lithium DD cells, up to 2 stacks of 4 cells; 60 Ampere-hours @ 14.4Vdc (17-inch sphere)
operating capacity	2 – 5 years in 17" sphere – depends on measurement schedule, options added, water depth and telemetry options used.
safety	parallel diodes on cells ensure series battery stack integrity, series diodes on each stack isolate stacks from each other

Intelligence_____

processor	Persistor™ CF1 with Motorola™ MC68CK338 microprocessor
crash protection	Independent system and release functions; "deadman" watchdog timer; low battery detection stops all except release functions

Mechanical_____

weight in air	36kgs (80 lbs) with full (180 Amp-hr) lithium battery pack 34kgs (76 lbs) with 120 Amp-hr lithium battery pack
buoyancy	16kgs (36 lbs) with 180 Amp-hr lithium battery pack 18kgs (40 lbs) with 120 Amp-hr lithium battery pack
shipping container	HAZMAT sealed polyethelene barrel
total shipping weight	57Kgs (125 lbs)

1.6   TRAVEL TIME MEASUREMENTS

Two primary measurements are taken by the IES: inverted-echo-sounding travel time, and (optionally) absolute bottom pressure. The travel time is the time it takes an acoustic pulse (12.0kHz @ 6 milliseconds) to travel from the IES on the seafloor to the sea surface and return, i.e., the time it takes to detect the surface echo

The IES processes 24 individual echo measurements to produce a single travel time. In a typical deep sea experiment, the ocean acoustic travel time sensitivity to changes in actual water surface height is about +1.3 milliseconds/meter (ms/m) with thermocline depth variations changing the travel time by approximately 0.05 ms/m.

To eliminate early echoes from reverberation and false targets, the IES echo detector is disabled immediately after the acoustic transmission for a period of time called the ***lockout time***. The detector is enabled again just before the anticipated surface echo. To minimize false echoes from fish and other weak targets, the IES ***acoustic output power level*** is adjusted for depth under firmware control so that the sea surface is the most viable target. The optimal *lockout time* and *output power level* are suggested by the IES firmware after the user estimates the deployment depth (see Chapter 2.3.3)… the user can override these suggestions.

1.7 PRESSURE AND TEMPERATURE MEASUREMENTS

An IES equipped with the pressure measurement option (PIES) uses a quartz pressure sensor made by Paroscientific, Inc. for high accuracy and resolution. Paroscientific's stated accuracy of 0.01% for this line of sensor is well established. Typical resolution of Paros sensors is better than 1 part per million, and under stabilized conditions, resolution can approach 1 part per billion. In the typical PIES application, where the temperature and pressure are changing slowly and are relatively stable, the estimated sensor resolution is 1 part in 10 million. In the PIES, the pressure channel electronics measure with a resolution of about 1:64,000,000; that's about 0.00016 psi or about 0.16 mm H_2O for a 10,000 psi sensor. This ensures that the PIES pressure measurement resolution is limited by the capabilities of the sensor and not by the PIES electronic circuits.

See additional technical and application notes at www.paroscientific.com

Warning: The resolution of the pressure measurement is proportional to the full-scale range of the sensor. Over-pressuring the sensor by 20% of full scale will result in permanent damage; use caution when choosing sensor ranges less than 10,000 psi.

1.7.1   PIES Measurement Technique

The Paroscientific Digiquartz™ pressure sensor output is a frequency modulated (fm), square-wave signal, i.e., the output frequency is a function of applied pressure. The PIES pressure channel measures this frequency by first dividing the signal frequency by 2^{19} and then measuring the time between two successive rising edges of the signal; this period is typically about 16 seconds. Any pressure change (noise) during this 16 second period is integrated into the result. The period measurement is made by counting a temperature calibrated 4.0MHz reference oscillator during the time between the rising edges of the pressure sensor signal. A similar technique is used to simultaneously measure the temperature signal from the Digiquartz™ sensor. The two period measurements (pressure and temperature) are then used, along with the specific sensor calibration coefficients provide by Paroscientific, to calculate the pressure in physical units.

The PIES 4.0MHz frequency reference circuit, used (as outlined above) in the PIES pressure and temperature measurements, employs an ultra stable crystal manufactured by Bliley Electric, Inc. The aging (drift) of this device is 1×10^{-9}/day after 30 days operation. The specified accuracy of the reference oscillator is +/-5ppm (re 4.0MHz) but is corrected for temperature (by the PIES) using the uncorrected temperature measurement from the Paros temperature sensor. In other words, the approximate temperature from the Paros sensor is first used to correct the reference oscillator output and then the corrected reference is used to determine the temperature and pressure measurements. After these corrections for temperature, the accuracy of the PIES pressure measurement remains within the 0.01% FS sensor specification stated by Paroscientific, Inc.

URI-GSO has empirically determined that an order of magnitude reduction in the long term drift characteristic of the Paroscientific DigiQuartz™ pressure sensor can be realized if the sensor is pre-stressed, i.e., hold the sensor at the anticipated deployment pressure (+/- 1000dbar) for some period prior to the actual IES deployment. This is particularly true for new sensors. Pre-stressing for two months is recommended. Be careful not to exceed the full scale range of the sensor.

1.8 IES PARTS LOCATION DIAGRAM

Take a few moments to look over the following diagram. The parts pointed out in the diagram are discussed in succeeding chapters of this manual.
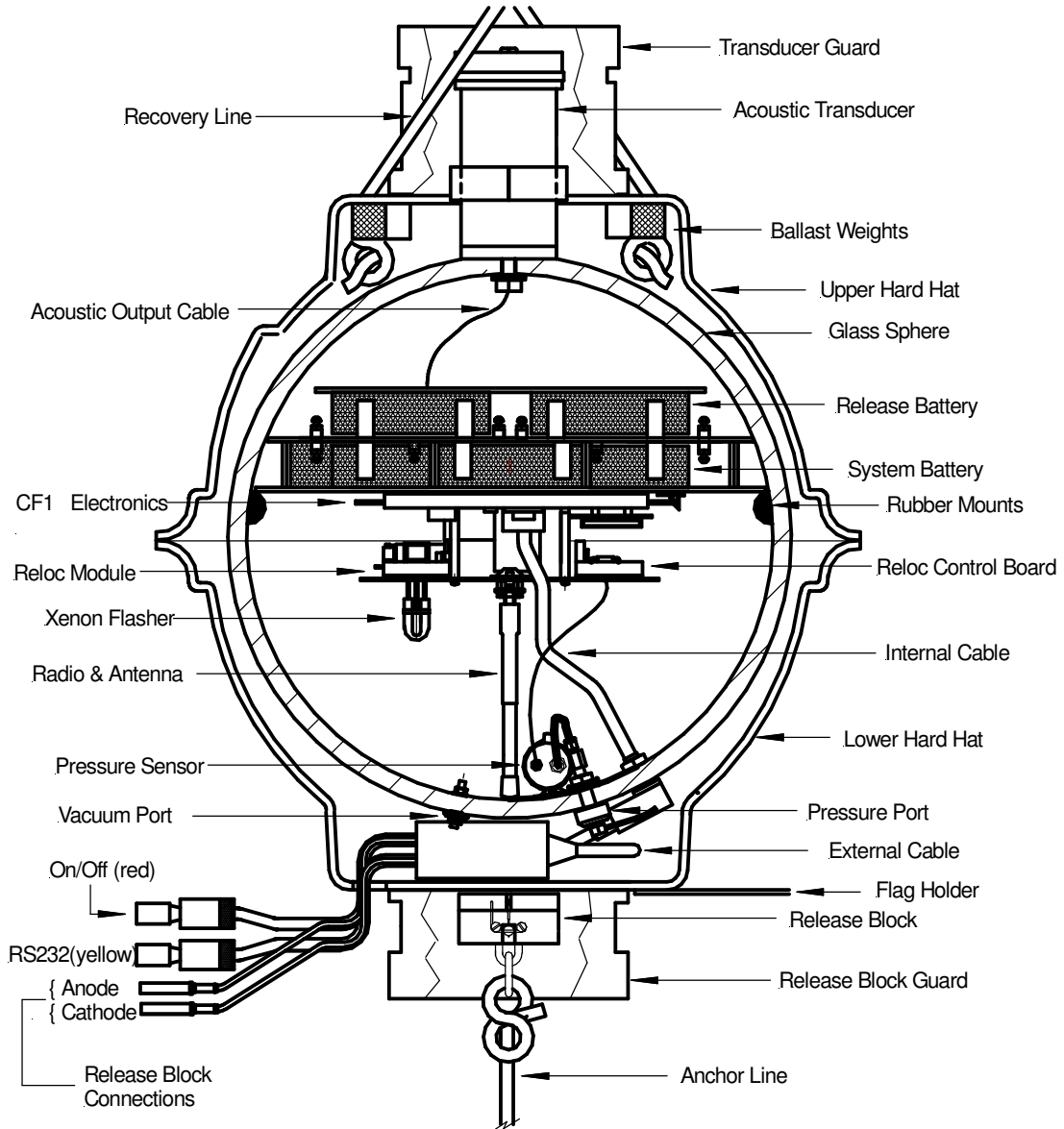
Figure 1-1   IES Model 6.2 Parts Location Diagram

Chapter 2   GETTING STARTED - CONFIGURING THE Model 6.2 IES

This chapter provides instructions on how to:
- use the internal and external switches and connectors
- understand the acoustic diagnostic signals
- establish communications with the IES
- use the menus to set up and start an IES mission

Note: As you read the following sections, keep in mind the parts location drawing (Figure 1-1) of Chapter 1.7. This diagram shows the location of many of the IES elements referred to in the text.

The Model 6.2 IES is usually shipped sealed, with its battery installed, ready to be turned ON, configured and deployed. Follow these steps after unpacking the IES:

1. Find the red ON/OFF plug that is taped or strapped to the IES housing.
2. Pull the IES external ON/OFF jack out of the lower hard hat and attach the red ON/OFF plug.
3. You should hear a single "ping", followed about 15 seconds later by a double "ping". This indicates that the IES computer has booted properly into data acquisition mode.
4. Remove the yellow RS-232 plug from the IES connector and attach the external communications cable between the IES RS-232 connector and the serial port of your computer.
5. Start the IES Hyperterminal communications program (See Chapter 2.2) on your PC and set up the serial port for baud 9600, 8bits, 1 stop, no parity and no hardware or software handshaking.
6. Remove the red ON/OFF plug from the IES and then plug it back in. The IES should RESET again (see Chapter 2.2.3) and the IES banner should appear on your computer screen. If trash characters appear, the computer serial port baud rate probably needs to be changed. The IES is shipped with a baud rate of 9600.
7. After the IES banner appears, you have 5 seconds to press the <space> key on your computer to go to the IES Main Menu.
8. Once you are at the IES Main Menu you can proceed to the following sections to set up your IES mission.

2.1 INTERNAL SWITCHES & CONNECTORS

Figure 2-1 displays the switches and connectors used in routine operations:
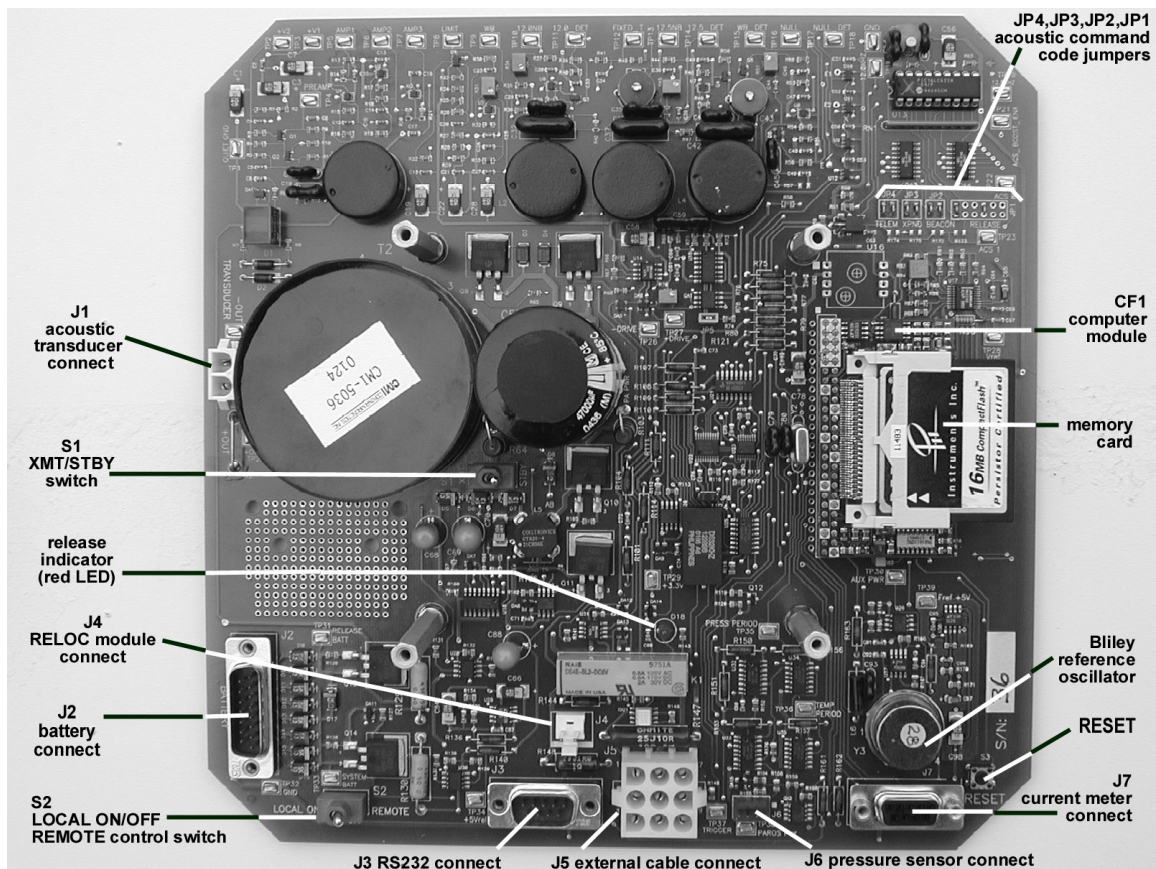
Figure 2-1   IES Model 6.2 Internal Switches and Connectors

- **S1** - turns ON/OFF the high voltage to the acoustic output driver. It should be in the XMIT position when the instrument is sealed up for deployment. It should be in the STBY position during periods of testing when there is a risk that the user may contact the high voltages on connector J1. ***DANGER: at full output there is 2500Volts at J1!***

- **S2** - overrides the external ON/OFF switch so that the IES electronics can be turned ON/OFF when the external cable is removed. ***It should be in the REMOTE position during deployment*** so that the external cable switch can control the ON/OFF function and in the LOCAL position when the IES is being tested with the sphere opened.

- **JP1**, **JP2**, **JP3**, **JP4** - these jumpers (or switches) encode the acoustic command system. The four types of commands and the number of code combinations for each are: TELEM (JP4 - 4 different codes), XPND (JP3 - 4 different codes), BEACON (JP2 - 4 different codes) and RELEASE (JP1 - 64 different codes). The selection and changing of acoustic command codes is outlined in Chapter 5.

- **RESET** - This push button will RESET the Persistor computer module and restart the IES program. A flow chart of the restart process is shown in Figure 2-3. All data collected since the start of that day will be lost unless they have been previously saved by a data buffer flush operation - see Chapter 2.5(F).

2.2 COMMUNICATIONS

Two custom RS-232 communications cables are provided with each Model 6.2 IES: one for direct communications when the glass housing is open (part # 54-11), and one for use when the sphere is sealed (part # 51-06). The IES RS-232 protocol is fixed at 9600 baud, 8 data, 1 stop bit, no parity. Any terminal emulation software capable of the above RS-232 protocol can be used to set up the IES; however, it is handy to have a "capture" feature to document testing and a reliable data file transfer protocol (YMODEM) to upload data files through the external cable. These software utilities are provided on the **IES User's Disk**.

An CD disk labeled "**IES User's Disk**" is provided with each Model 6.2 IES and contains two directories: Hyperterminal and MotoCross. **Hyperterminal.exe** is used to communicate and offload data from the IES and **MotoCross.exe** is used to load new IES firmware if necessary. Additional directories may exist depending on what options were installed.

Hyperterminal™ is a communications program bundled with MicroSoft™ Windows software in the *c:\programfiles\accessories\communications* directory… if you do not have it, copy the IES disk **Hyperterminal** directory to your computer and create a desktop shortcut to "**IES.ht**". If you already have a **Hyperterminal** directory, install only "**IES.ht**" and "**ies.ico**" in that directory, then create a shortcut on the desktop to "**IES.ht**". If you then right click the desktop icon and select properties, you can change the desktop icon to the special URI-GSO IES icon.

MotoCross™ is a communications program specifically designed to load new application programs to the IES CF1 computer module. Copy the MotoCross directory from the IES User's Disk to your computer and create a desktop shortcut to "MotoCross.exe". Instructions for loading new IES firmware are provided in Chapter 9.5

2.2.1   Communications Setup

There are two ways to set up communications with the Model 6.2 IES… follow *either* of these steps:

- *When the glass housing is open*, connect the RS-232 cable (p/n 54-11) directly to the IES circuit board at connector J3. With your computer running IES.ht, press the RESET button on the IES board and follow the prompts to reach the IES Main Menu.
- *When the glass housing is sealed*, connect RS-232 cable (p/n 51-06) to the external communications connector shown below. RESET the IES by disconnecting, and then reconnecting, the external ON/OFF plug and follow the prompts to the IES Main Menu. A diagram of the through-the-glass control cable is shown in Figure 2-2.
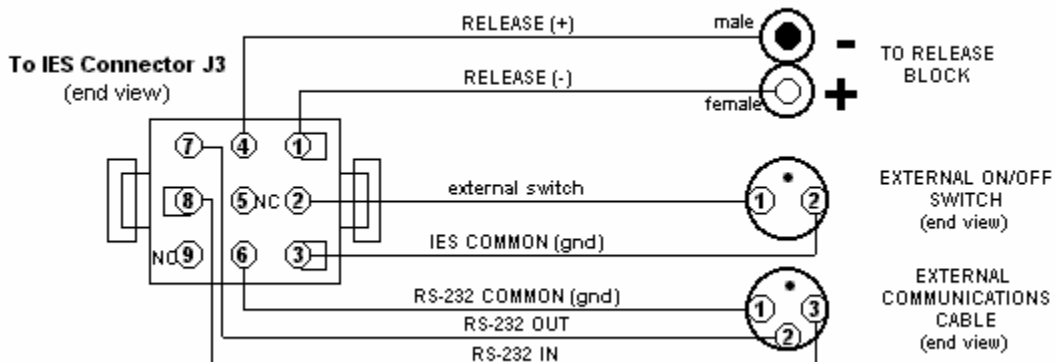
Figure 2-2   IES Model 6.2 -- Through-the-Glass Communications and Control Cable

2.2.2   RESET Sequence

For those who want to know the details, a flow chart of the power ON or RESET function is shown in Figure 2-3. The most important details are listed below.

- Pressing the RESET button or power cycling (OFF/ON) restarts the model 6.2 IES.
- Listen (or watch the PC screen for "*ping") for a single ping that indicates the IES has begun its initial start-up tests.
- If a communications cable is attached, the user has 5 seconds to press the <space> key to enter the menu mode.
- If no <space> key is detected, the IES will check the battery voltages and currents, verify that there is enough memory to store data until the auto-release date, and then (5 - 30 seconds after the 1st ping) transmit two pings (and display "*ping" twice on the computer screen) to indicate that the IES has entered the data acquisition mode. If a computer is attached to the IES, the operating configuration parameters and the IES clock setting will be displayed on the terminal where it can be captured for the record.
- If a PC is not attached and the "two ping" signal is *not* heard, attach the communications cable and a PC with Hyperterminal running and repeat the RESET. Monitor the messages displayed on the PC to diagnose the problem.

**Power ON or
RESET**

initialize the CF1

configure I/O lines

get the last mission
configuration saved

enable the watchdog

clear the release relay

create an ies_***.log file
(if none exists) and
write a RESET record

1st 'O.K' *ping

keystroke
input? — Yes →

loop for 5
seconds

No

check voltages & currents

calculate mission memory requirement

check capacity of flash card

all systems
GO? — No → report error

Yes

display mission configuration
& engineering data

two 'O.K.' *pings
0.3 seconds apart

any engineering
files exist?

No

create a new set of data files: (if enabled)
T***_xx.dat
P***_xx.dat
E***_xx.dat
F***_xx.dat

write metadata records in
all three data files

Yes

clear the day buffers (RAM)

write an OPERATE record

enable & reset the watchdog (11 min)

Data Acquisition Loop

disable
watchdog

exit to PicoDOS C:> prompt (no return)

MENUS

GO - display latest mission
configuration & engineering data

save configuration
and start mission? — No →

Yes

check voltages & currents

calculate mission memory requirement

check capacity of flash card

all systems
GO? — No → report error

Yes

SAVE mission configuraton

write an OPERATE record

create a new set of data files:(if enabled)
T***_xx.dat
P***_xx.dat
E***_xx.dat
F***_xx.dat

write metadata records in
all data files

clear the day buffers (RAM)

enable & reset the watchdog (11 min)

Figure 2-3   IES RESET program flow

2.3 USER INTERFACE – MENU MODE

Previous sections describe how to access the IES menus by resetting or power cycling the instrument.   The menu mode is also accessible *without* performing the RESET routines, i.e., without clearing the day buffers (RAM) and without creating any new data files. See the next section for a description of the wake up cycle.

2.3.1   One Minute Warning

By referring to the clock used to set the IES internal clock, the user can determine *exactly* when the instrument will perform its data acquisition tasks. If the user wishes to establish communications with the IES without using the RESET function (power cycle OFF/ON or RESET push button) there is a *two second "window of opportunity"* every ten minutes to do so. These windows of opportunity begin ten seconds prior to the ten minute mark of the time reference mentioned above, e.g., at **:09:50, **:19:50, **:29:50, etc., after the hour. To make it easy for the user to be ready for this small window, a one minute warning is sent as a prompt at the nine-minute mark, e.g., **:09:00, **:19:00, **:29:00, etc.   After the one minute warning, the user can simply hold down the <space> key on the computer and the IES will enter the Main Menu when it wakes up 50 seconds later. In other words, the one minute warning occurs 50 seconds before the start of the "window of opportunity" for communications, and 1 minute before the next set of data acquisition tasks.

2.3.2 IES Main Menu

Once communications has been established, the IES Main Menu will appear, similar to the screen below. The top banner lists any optional sensors that have been installed.

```
🐞 IES - HyperTerminal                                                    ⬜🗖❌
File  Edit  View  Call  Transfer  Help
         Inverted Echo Sounder Model 6.1E - Version: May 12 2004 20:23:41      ▲

            Serial No.129  Optional Sensors Installed: pressure sensor
         University of Rhode Island - Graduate School of Oceanography
     ***********************************************************************
       Current IES day, date and time is Mon Dec  6 16:03:57 2004

       Adjusting transmitter power... wait


     \DATA

       RESET record written to system.log...
       *ping

       Press the <space> key within the next 10 seconds to enter the IES Main Menu,
       otherwise data collection will start with previous operating parameters.


     ***************************** IES Main Menu ****************************
       A ---- Self-Test Menu
       B ---- Memory Card Menu                                 |
       C ---- Mission Setup & START Menu
       X ---- RESET
     -                                                                         ▼
Connected 0:06:08      ANSI      9600 8-N-1     SCROLL   CAPS   NUM   Capture   Print echo
```

A ---- Self-Test Menu

The Self-Test Menu contains selections of functions that can test virtually all of the IES circuits. Some of the menu selections require additional test instruments, e.g., the travel time test requires an echo simulator and the reference oscillator test requires a frequency counter. Details of each test and the supplementary test equipment required are provided in Chapter 3.

B ---- Memory Card Menu

The Memory Card Menu allows the user to examine and read the memory card data files as well as prepare the card for a data acquisition mission and offload files to a computer. Details of each memory card menu selection are provided in Chapter 2.5.

C ---- Mission Setup and START Menu

The Mission Setup Menu is essentially a list of programming options that MUST be selected prior to deploying the IES. These selections determine the behavior of the instrument's data acquisition subsystem during the subsequent deployment. The menu is self-explanatory and the ranges of selections are indicated… invalid operating parameters will not be accepted. Details of each selection are provided in Chapter 2.4.

D ---- RESET

This selection will RESET the IES *without saving any changes* that may have been made while in menu mode. Changes will be lost unless they were saved by the SAVE or the GO selection in the Mission Setup Menu. See Chapter 2.2.2 for a description of the RESET process.

2.3.3 IES Mission Setup Menu

       A ---- **Set date/time clock**   displays the current IES date and time. To modify the time, enter a date/time that is slightly ahead of your timepiece and press <enter> when the times match… the new time will be saved and will remain accurate even when the IES is off. To confirm the correct time, select "A" while monitoring your timepiece and compare the times. After selecting "A", simply pressing <enter> without entering a valid time will leave the timing unchanged.

       B ---- **Select travel time measurement schedule**   displays the current schedule and other options, including disabling the travel time measurements. To change the schedule, select an option and the new schedule will be displayed. Note that a new schedule has not yet been saved to non-volatile memory… this will not happen until data acquisition has started and the entire mission configuration is saved (see selection S or G).

       D ---- **Enter water depth, lockout time and output power level**   displays the current value of estimated water depth (in meters) and prompts the user for a new value. For no change in depth value, press <enter>. Water depth is the primary consideration that determines the lockout time and the output power level. After estimating the depth at the deployment site, the IES will suggest the proper lockout time and output power level. To accept these values, press <enter> after each current value is displayed. See Chapter 1.5 for some further discussion of travel time measurements.

           The water depth is solicited so that the IES instrument can advise the user of a suitable lockout value. The user can override these suggestions by entering other values as long as they do not violate the basic measurement principles, e.g., you cannot enter a lockout time that would block the sea surface echo. The selection of lockout time and output power level is critical to the mission success and is dependent upon the depth at the deployment site**.** ***The IES will not operate usefully if deployed in water shallower than estimated here.*** The lockout time and output power level will not be saved in non-volatile memory until the SAVE or GO menu selection (S or G) is made (see below).

E ---- **Enter auto-release date and hour**   displays the current automatic release date and hour and prompts the user for a change. This is the date and hour when the IES will release its anchor and rise to the sea surface without user intervention. Data acquisition will stop and the IES will initiate a 4-second acoustic beacon. The IES will not start the data acquisition mission unless the auto-release date and hour are in the future AND there is enough data storage available on the memory card to operate until the auto-release date. *Note: The auto-release is not the primary method of IES recovery. An acoustic release is the routine method. The auto-release is a back-up in case the acoustic release system should fail.*

F ---- **Enable/disable the acoustic data telemetry file**   Enables the daily processing of data for transmission via the telemetry link. If the file is enabled, the IES will process the travel time, pressure and any other sensor data at the end of each day. See Chapter 10 for a description of the TELEM.DAT file and the various formats associated with each sensor suite.

H ---- **Enter a mission statement**   the user is prompted to enter a line of text as a mission statement. To assist in data record keeping, a line of text (mission statement) is written to the system log file when data acquisition starts. This might be a site location, a project name, etc. End the statement (80 characters maximum) by pressing the <enter> key. The mission statement does not get saved with the operating parameters so it is valid for the subsequent data acquisition mission ONLY if the mission is started with the GO selection (see below)… it will NOT be saved by the SAVE selection and will be lost if the IES is turned OFF prior to new data files being created (see Chapter 4.2).

S ---- **SAVE mission configuration**   will write all of the current operating parameters to non-volatile memory.   If the IES is turned OFF after a SAVE, any changes to the mission configuration will be saved and a new set of data files will be created when the IES is turned back ON. Note: It is o.k., but not recommended, that you start a mission this way. There is no configuration review. You should carefully review all of the operating parameters prior to starting a mission (see the GO selection below).

G ---- **GO - review configuration and START data collection**   displays the entire mission setup and prompts the user for approval to start the data acquisition mission. If, after review, further modifications are required, the user can return to the mission setup menu or continue to the final IES self test before starting the mission. In the final self-test the IES will measure battery voltages and currents, make sure there is enough memory for the entire mission, create a new set of data files on the memory card, write the appropriate meta-data records and *start the data acquisition process*.   At this point the user can disconnect the communications cable from the IES or continue to monitor the operations… the IES will display operating notes as it performs its data acquisition functions. After this step the user can turn OFF the IES and ship it to the deployment site… when the IES is turned back ON, the "saved" mission and the clock setting will be preserved and the mission will start without any further communications. During this final step before starting a mission it is a good idea to turn on the "capture" mode of Hyperterminal™ and save a record of the setup as the IES starts its mission

2.3.3.1 Saving a New Mission Configuration

Modifications to the mission configuration (measurement schedules, timed release, sensor coefficients, etc.) made while in any of the above menus will be *saved only when the user selects SAVE or GO from the Mission Setup Menu…* so *do not* change values and then shut OFF or RESET the IES… your new values will be lost! The *mission statement* text will be saved *only* by using the GO selection to start a mission.

2.3.4   Optional Sensor Setup Menus
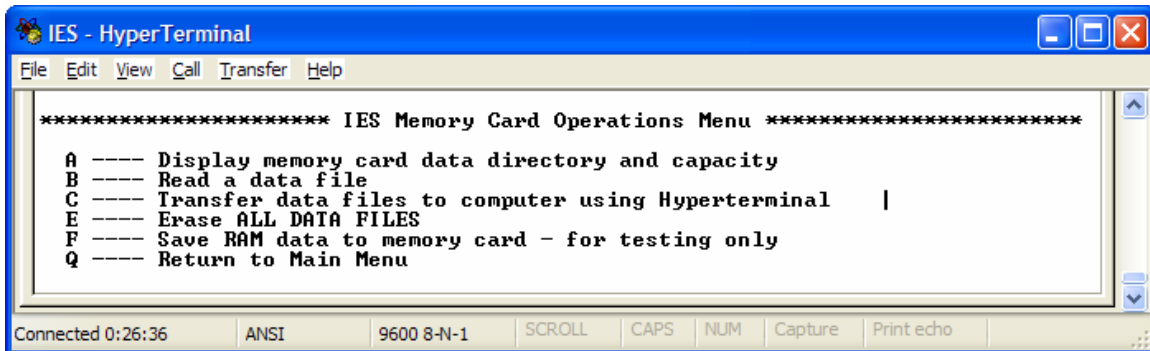
There may be additional setup menus, depending on the optional sensors installed. For example, the menu shown below will be available when the pressure sensor is installed. If *no* additional sensors are installed, the 'Optional Sensors' list in the Mission Setup Menu will not be displayed. See Chapter 11 for a description of the Doppler Current Setup Menu.
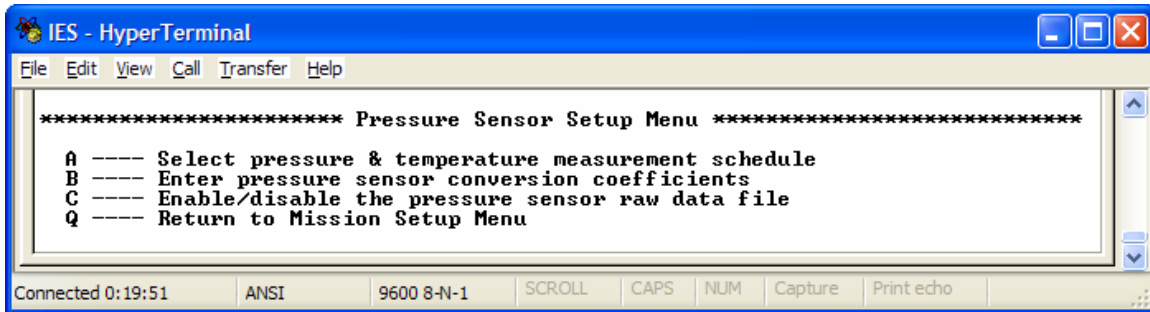
A ---- **Select pressure & temperature measurement schedule**   displays the current schedule and other options, including disabling the pressure and temperature measurements (if there is no pressure sensor). To change the schedule, select an option and the new schedule will be displayed. Note that the new schedule has not yet been saved to non-volatile memory… this will not happen until data acquisition has started and the entire mission configuration is saved (see selection S or G).

B ---- **Enter pressure sensor conversion coefficients**   displays the serial number of the pressure sensor and each of the sensor's calibration coefficients. The user is prompted for modifications. The serial number and temperature coefficients of the Bliley reference frequency oscillator crystal are also displayed and modifications solicited. The pressure sensor and oscillator are not "smart" devices, i.e, the user must load the serial numbers and coefficients… the IES does not detect them. The proper values are set initially for the sensor and crystal provided with the instrument and a copy of the coefficients is shipped with the documentation packet for each IES. If the pressure sensor or reference oscillator crystal is changed, a new set of coefficients must be loaded.

C---- **Enable/disable the pressure sensor raw data file**   The signals (pressure and temperature) output from the Paroscientific pressure sensor are frequency modulated square waves whose frequency is a function of the applied pressure and ambient temperature. This menu selection enables/disables the saving of the frequency measurements in case there are any questions regarding the validity of the conversion (to engineering units) process applied by the IES. The format of the raw data file is identical to the converted data file except that the units are in milliHertz. The IES computer will attempt to remove any wild points from the pressure and temperature converted data, but will *include* these wild points in the raw data file.

2.3.5   IES Memory Card Menu

From the IES Main Menu select "B" to enter the Memory Card Menu. Your display should look similar to the following:

A ---- **Display memory card directory and capacity**   displays the name, size and date of creation of each file on the memory card as well as the number of free bytes available on the card.

B ---- **Read a file**   displays the directory (as above) and prompts the user for the name of a file to be read. When the file name is entered, the file contents will be displayed. This is the equivalent of the MS-DOS "TYPE" command.

C ---- **Transfer data files to computer using Hyperterminal**™   displays the directory (as above) and prompts the user to enter the index of the data set to be transferred to a computer directory. When a data set index is entered, the display will list the available files and prompt the user to continue. If the user enters 'Y", the IES will respond by displaying the filenames and message "sending *filenames*". ***The user must then click the right mouse button and select "receive file*". When the Hyperterminal™ file transfer window opens, enter the destination directory and select "YMODEM" as the transfer protocol. Click OK and monitor the status window for any transfer errors.

E ---- **Erase ALL files - format the memory card**   erases ALL files on the memory card. There is no recycle bin… when this operation is performed; all data will be irretrievably lost! The user will be warned and asked to approve the operation. To approve the operation the user ***must enter an uppercase* "Y"**.

F ---- **Save RAM data to memory card - for testing only**   transfers the data in volatile RAM buffers to non-volatile memory card data files. During routine operations, this data transfer takes place at the end of every day ***and*** when the IES senses that the RELEASE relay has been activated. It is included here to allow the user to move data from RAM to the memory card after IES testing in the laboratory. There are important details about this process in Chapter 4.2.3.

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Chapter 3   ADVANCE PLANNING & PREDEPLOYMENT TESTING

This chapter will provide instructions on how to:
- determine the specific mission requirements
- test the IES before deployment

3.1 ADVANCED PLANNING

Advanced planning involves the IES user answering the following questions:
- how often do I need IES travel time measurements?
- do I need a pressure measurement at the site?… how often?
- how long do I want to deploy this IES?
- what is the water depth at the deployment site?
- any special precautions at the site (high currents, fishing activity, unusual topography, etc.)?
- what date and time shall I set the auto-release ?

The implications of the various answers to these questions are addressed in this section.
Discussions on the choices of:
- travel time measurement schedule
- pressure measurement schedule
- battery pack capacity and loading
- output power
- lockout time
- special mooring requirements
- auto-release date and hour

For the general planning of an IES deployment, the following time-chart shows what needs to be done, when and where to find relevant information.

Time	Operation	See Chapter
4 months before	order batteries & expendable parts	3.3, 6.1, 7.3, 7.4, 9.4
3 months before	check condition of IES mechanical parts	7 & 9
2 months before	pre-stress the pressure sensor	1.6.1
4 weeks before	preliminary electronics tests with test battery	2 & 3
2 weeks before	load new batteries & de-passivate battery pack	3
	configure the mission, final test at 25°C	2
1-2 weeks	Vacuum seal the IES housing	7
	2 day IES test with echo simulator @ 0°C	Test Accessories Guide
	test ACS subsystem @ 0°C	5
	test RELOC module @ 0°C	8.2.3
1 hour before	set the IES clock, clear memory card	2.4, 2.5
	fill out Deployment Form	Appendix E
	attach anchor & flag	8
	check the vacuum indicator	7 & 8
at deployment	test for false release	Test Accessories Guide
	record position and time	Appendix E

3.2 SELF-TEST MENU
    The following describes the functions available from the IES Model 6.2 Self Test Menu:

```
IES - HyperTerminal                                                    [_][□][X]
File  Edit  View  Call  Transfer  Help

******************************* IES Self Test Menu *******************************
   A ---- Ping Test: 10 pings at programmed output level (4 sec.rate)
   B ---- Travel Time Test: a single TT measurement
   C ---- Precision frequency reference test -- measure on CF1, pin 35
   D ---- Pressure sensor test: a single P&T measurement pair
   G ---- Output Power Test: accurate with ITC 3431B transducer only
   H ---- Check memory card
   J ---- View Engineering Data
   K ---- Release Relay Test -- ON for 30 seconds
   Q ---- Return to Main Menu                                           |

   _

Connected 0:00:55        ANSI        9600 8-N-1      SCROLL  CAPS  NUM  Capture  Print echo
```

A ---- **Ping Test: 10 pings at programmed output level (4 sec. rate)** tests the acoustic output. An oscilloscope with a high voltage test probe can be attached to measure the voltage across the acoustic transducer and the pulse length. Important: before selecting this test, attach the oscilloscope probe with the ground lead on -OUT and the high voltage probe on +OUT. These test points are near connector J1 (see Figure 2-1)

The output voltage should measure $= 150 \times 10^{(\text{programmed level, dB} - 172.4)/20}$ Volts, p-p

For example, for a programmed level of 188,
Output voltage $= 150 \times 10^{(188 - 172.4)/20} = 904$ Volts, p-p

DANGER: Highest output voltage (for output level= 197dB) will be 2500Volts peak-to-peak!

B ---- **Travel Time Test: a single TT measurement** tests the echo detector. In order to detect an echo you must provide a simulated one. If a URI-GSO echo simulator is available, attach the box's INPUT cable to the TRIGGER (TP37) of the IES model 6.2 and the OUTPUT of the echo box to either one of the signal insertion cable's input connectors. The signal insertion cable itself must be attached to TRANSDUCER (J1) of the IES. With this test setup, the IES should report a travel time within 1 milliseconds of the echo simulator setting. *See the Test Accessories Users Guide for details on using the Echo Simulator.* If the URI-GSO Echo Simulator is not available, a 12.0kHz acoustic pulse (any length > 6 milliseconds) through a speaker aimed at the IES transducer and time delayed with a stopwatch will provide a qualitative test of the echo detect circuits.

C ---- **Precision frequency reference test – measure on CF1, pin 35** turns on the Bliley 4.0 MHz frequency reference circuit for 15 seconds… measured with a frequency counter at pin 35 on the CF1 connector. Note: There is a small white dot on the main circuit board next to CF1-35. With no temperature correction, this measurement should not be more than +/- 4 ppm (16Hz) in error from 0 to 25°C.

3.2   SELF TEST MENU (cont'd)

D ---- **Pressure Sensor Test: a single P&T measurement pair**   tests the pressure, temperature and frequency reference (4MHz) circuits. This menu selection will appear ***only*** if the optional pressure sensor is installed. If no pressure is applied to the IES pressure port, the measurement should indicate approximate barometric pressure and ambient temperature ***if the IES is oriented with the acoustic transducer facing UP***. If a calibrated pressure is applied to the pressure port, the IES should measure within 0.01%FS of the pressure applied. *Warning: applied pressure must not exceed the pressure rating of the sensor.*

G ---- **Output Power Test**   measures the power, in Watts, delivered to the acoustic output transformer. This test charges the output capacitor (C57) to the programmed output level, reports the voltage at the capacitor before and after a single ping, then calculates the power delivered to the output circuit based on this voltage difference. To be accurate, this test should be done with the ITC 3431B transducer in water… especially at high output levels. A wide range of acceptable test values are displayed that indicate the variability of the transducer when driven in air.

H ---- **Check memory card sectors**   checks each sector of the memory card to determine the integrity of the write/read process. Any defective sectors will be reported.   Any errors here indicate the memory card should be replaced.

J ---- **View Engineering Data**   reports the current values of the battery voltages, system currents and the internal temperature. Acceptable ranges are indicated.

K ---- **Release Relay Test**   activates the release relay (and the radio/flasher RELOC module, if attached) for 30 seconds. The release indicator (red LED on the circuit board – see Figure 2-1) will light during the test period period. This test checks the relay driver circuits and can be used to test the external release block cables, release block connectors and RELOC module operations (see Chapter 8.2.3).

3.3 BATTERY LIFE

  Note: As of this printing (January 2005) the only battery cells suitable for the IES Model 6.2 battery pack is the size "DD" lithium thionyl-chloride (LiSOCl$_2$). Two recommended sources are:
➢ *Tadiran® Inc. (model no. T-5137-/T). Contact their web site <u>www.tadiranbat.com</u> for the address of your local distributor.*
➢ *ZenoEnergy Co., Ltd.® Inc. (model no. XL-205F/1S2P/T1). This is a proprietary cell configuration that will require an approval-of-purchase from URI-GSO.*

  There are two batteries in the IES; a *system* battery to power the data acquisition functions, and the *release* battery to power the acoustic command functions… we will refer to the mechanical package that houses these two batteries as the 'battery pack'.
  To determine the proper <u>system</u> battery capacity for a given mission, refer to Figure 3-1.
  There are only two mission configuration selections that influence the battery requirement; the depth of the deployment site and pressure measurement rate… both of these selections are made by the user in the Mission Setup Menu (see Chapter 2.3.3). After the user has entered the depth estimate, the IES will recommend the appropriate output power level… the power level must be known to use Figure 3-1. Knowing the output power level and the pressure measurement rate the user can find the average system battery drain and life-expectancy of two configurations of IES system batteries: 120 Amp-hr and 180 Amp-hr. Follow the example below the figure.
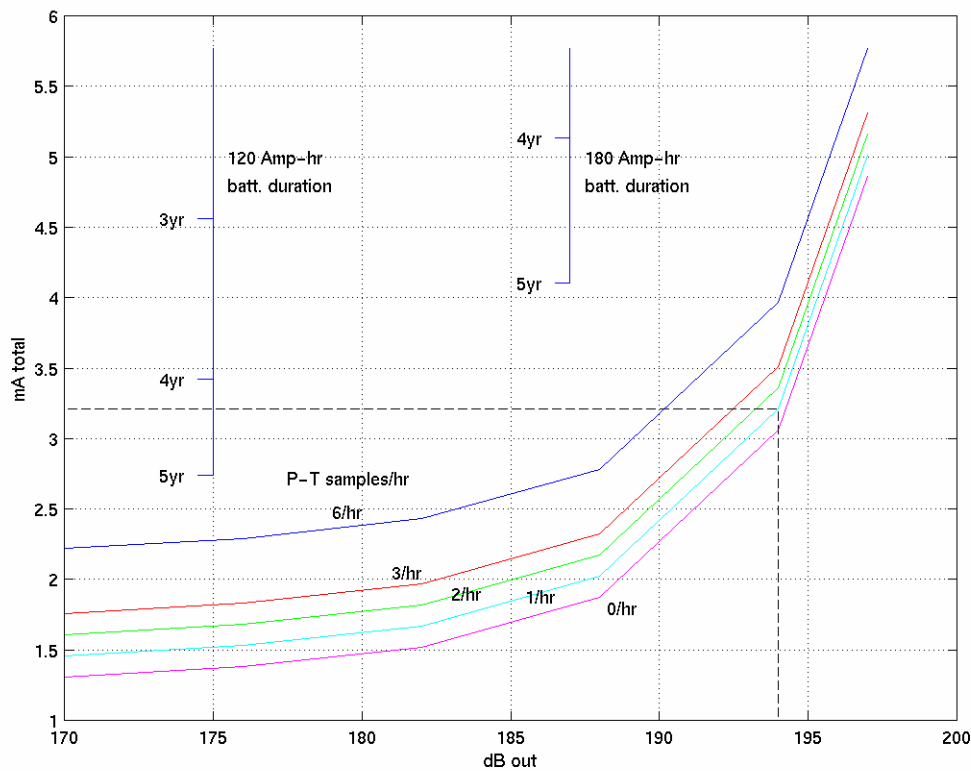
Figure 3-1   Total average current (mA) drawn from the battery pack for a chosen output power level (dB) and pressure-temperature sampling rate.

 Example: When the user enters a depth of 5500 m, the **IES Mission Setup Menu** (selection "**D**") recommends a power level of 194 dB. Having chosen this power level and a P-T sampling rate (selection "**C**") of one per hour, follow the vertical dashed line at 194 dB to the point where it intersects the "1/hr" curve. Then follow the horizontal dashed line from this point to the current axis, showing an average current drain of 3.2 mA. This horizontal line lies below the "4yr" mark on the "120 Amp-hr batt. duration"

stave, indicating the 120 Amp-hour battery has sufficient energy for a 4-year deployment. The line is above the "5yr" mark on this stave, indicating the 120 Amp-hour battery does not have sufficient energy for a 5-year deployment. But the line lies below the "5yr" mark on the "180 Amp-hr batt. duration" stave, so the higher capacity battery is capable of powering the instrument for 5 years with this mission configuration.

Always configure the release battery as a double stack (60 Amp-hrs). This will eliminate problems due to passivation (see section 3.3.1) an will support the acoustic command functions (with a 20% safety margin) for 5 years, regardless of mission configuration.

IMPORTANT BATTERY NOTES:

- *The shelf-life of a lithium cell is ten years, however, a conservative 20% safety margin should be added to the above <u>system battery</u> calculations to make up for any optimism in the battery manufacturer's specification, low temperature operations and for long communications sessions, e.g., repeated setup sessions, final testing and data offloading. Communications uses up about 0.045Amp-hr/hr.*
- *If the <u>system</u> battery becomes exhausted during the experiment, it is not catastrophic…the CF1 computer will sense that the battery is getting low and gracefully shut down the data acquisition circuits. The release battery will then take care of routine recovery operations… however, after the system battery shuts down, the auto-release timer is no longer active.*

3.3.1 Replacing the Batteries

The number of cells required on a battery board is dependent on the mission energy requirements as outlined in the previous section. However, after the system battery capacity is determined, the position of the cells on the battery board is important in order to properly ballast the IES so that the acoustic transducer is vertical during deployment. Cells should be loaded such that the battery board center of gravity remains in the middle of the board… with a little examination of the diagram on the board and the circuits outline in Chapter 6, you'll see that this is possible for system battery (top of board) capacities of 90, 120, 150, 180 and 240 Ampere-hours. The release battery (bottom of board) can be configured for 30 or 60 Ampere hours (1 or 2 stacks) with both configurations' center of gravity being in the center of the board.

3.3.2 De-Passivating the Battery Pack

Lithium batteries are affected by a phenomenon known as passivation. Passivation is a film of lithium chloride(LiCl) that forms on the surface of the lithium anode, and it serves to protect the lithium from discharging on its own when the load is removed from the cell. The film of LiCl, which is essentially a high resistance layer between the electrodes, is primarily responsible for the long shelf life (>10 years) of lithium cells.

Passivation may cause voltage delay after a load is placed on the cell. When the cell is loaded, the high resistance of the passivation layer causes the voltage to dip. The discharge reaction slowly removes the passivation layer thereby lowering the internal resistance of the cell. This in turn causes the cell's voltage to reach a peak value which should remain steady if other discharge conditions do not change. If the load increases after the cell's voltage stabilizes, then it may dip again until the passivation layer is sufficiently removed.

Battery cells that have been on the shelf for many weeks or exposed to high temperature may cause the IES supply voltage to dip below the minimum requirement and cause the instrument to reset. Since it is impossible to know how long new cells have sat without a load since their manufacture, it is wise to deliberately load the cells prior to use until the passivation layer is removed. Once the cells have been cleaned (de-passivated) the routine data acquisition operations of the IES will keep them clean.

URI-GSO provides a battery tester and de-passivator for this purpose. This instrument will intermittently (push-button control) load each individual battery stack in an IES battery pack to its maximum current capability. The user can monitor the voltage during the loading process to determine when the passivation layer has been removed and the voltage no longer drops below minimum values.

3.4 DATA ACQUISITION SCHEDULES

There are two data acquisition schedules that must be configured before starting an IES mission: the travel time measurements and the pressure/temperature measurements (if the optional high pressure sensor is installed). A third measurement schedule, the engineering data, is on a fixed schedule of once per day as outlined below. These schedules may be independently chosen, and all are synchronized to the real time clock as described below.

   3.4.1   Travel Time Measurements

If the travel time (TT) measurements are enabled, there are *always* 24 TTs in an hour. The user can program how these 24 measurements are spaced within the hour. The TT measurements are grouped in bursts, such that one burst/hour programs 24 TT measurements in a single burst, two bursts/hour programs 12 TTs in two bursts… to six bursts/hour with 4TTs/burst. All of these bursts begin precisely at ten minute increments of the real time clock (RTC)… for example, 1 burst/hr starts precisely on the hour, 2 bursts/hr start on the hour *and* at 30 minutes after the hour, etc. Within the bursts, the individual TT measurements are timed to alternate between a 16 and 18 second rate to prevent aliasing in the data.

   3.4.2   Pressure & Temperature Measurements

The pressure and temperature measurement schedules (since they are made with the same sensor) are identical and will be referred to as a single P&T measurement schedule. If the pressure sensor is installed and the P&T schedule is enabled, the user can choose from one, two, four or six P&T measurements per hour.   Like the TT measurements, the P&T measurements are synchronized with the real time clock (RTC) 10 minute marks but will occur *after* the TT measurement burst if scheduled at the same 10-minute mark, or *precisely* at the 10 minute mark, if *not* scheduled with the TT measurement. In other words, the TT measurement has priority if the two measurements (TT and P&T) are scheduled for the same time.

   3.4.3   Pressure & Temperature Raw Data Measurements

If the P&T frequency data file collection is enabled (see Chapter 3.4.3 & 4.2.1), a separate file will be created to store the raw frequency data from the pressure and temperature sensors. These data will be collected on the same P&T schedule described above. Errors in P&T measurements may be caused by the sensor itself or the conversion process. This feature is primarily a diagnostic tool to determine if the P&T sensors can be eliminated as the source of error.

   3.4.4   Engineering Data Measurements

Engineering data, as described in Chapter 4.3.2, are collected once per day, at the end of the measurement day (at 23:50:00 hours or *after* any measurements scheduled for 23:50 hours). This schedule is always enabled and cannot be modified by the user.

   3.4.5   Memory Card Operations

To minimize power consumption, the Model 6.1 IES collects a day's worth of data in RAM before it writes to the non-volatile memory card, i.e., the memory card is activated once per day to transfer data from RAM to the card. This write operation is synchronized to the real time clock (RTC) of the CF1 computer module to occur at the end of the data acquisition day (at 23:50 hours or after any scheduled 23:50 operations). At the beginning and end of a mission, there will most likely be partial days written to the card. The data transfer operation will also occur when the IES detects an acoustic or auto-release function.

3.5   MEMORY CARD CAPACITY VS. DEPLOYMENT TIME & SAMPLING SCHEDULE

The standard IES Model 6.2 memory card capacity is 32Mbytes. If both travel time and pressure/temperature measurement schedules are enabled, the requirement for memory space is 8500 bytes/day… so the standard card will support 5 year deployments. There are larger memory cards available (up to 192Mbytes!) to support longer deployments or custom, high-capacity data collection schemes. Consult URI-GSO for assistance in customizing schedules and memory capacity.

The memory card capacity influences the auto-release date and time selection (see Chapter 3.7). If there is not enough memory capacity to allow the IES (as it is currently configured) to collect data until the auto-release date, the IES will not allow the mission to start. To abandon the auto-release feature, you cannot put the auto-release date so far in the future that the memory capacity requirement, as stated above, is violated. At this time (2005/10/10) the standard memory card size is 32 Mbytes… this should allow the user to program the auto-release date far enough in the future, without compromising the memory requirement or the mission startup, to effectively disable the auto-release feature.

Table of Memory Requirements vs. Sampling Schedule
Includes requirements for pressure (P&T) and Doppler current sensor (DCS) options

Requirements, in bytes, for 30 days deployment

| | Sample rate | | | |
Record type	10 min.	20 min.	30 min.	60 min.
Tau	125K	125K	125K	125K
P&T	23K	17K	15K	14K
DCS	439K	220K	110K	55K
Eng	3K	3K	3K	3K
Telem	1K	1K	1K	1K
Sys log*	---	---	---	----

---

*will depend on errors during operations… no problems == no error messages == no data

Examples, using the table:
For: tau@10min, P&T@10min, DCS@10min = 591K/30 days ~= 7.1M/yr
For: tau@10min, P&T@10min, DCS@20min = 372K/30 days ~= 5M/yr

Standard instruments have a data capacity of 32Mbytes.

3.6 Temperature and Pressure Offsets

The Paroscientific pressure sensor temperature measurement is accurate to +/- 2°C. This is good enough to calculate temperature compensation for the pressure measurement, but not acceptable to provide temperature compensation for the Bliley reference frequency oscillator which is used in the pressure measurement. Paroscientific, Inc has assured URI-GSO that the poor accuracy is a fixed offset error that can be corrected by measuring a known ambient temperature with the IES and entering a zero offset value to make the measured value the same as the true value. To confirm that the proper pressure and temperature offsets are installed in your PIES, let the sealed up instrument reside at a known, stable temperature for 6 hours and follow these steps *with the IES acoustic transducer facing UP*:

1. Select "**D**" from the IES **Self Test Menu** and note the reported temperature value.
2. *Subtract* the *reported* temperature *from* the *known* temperature and note the difference as **Tdif**, in degrees C. Don't forget to note the sign of the **Tdif**.
3. Go to the IES **Mission Setup Menu** and select "**H** - **Enter pressure sensor conversion coefficients**". When queried to modify coefficients, enter "**N**" until you reach **Tzero**. *Add* **Tdif** to the **Tzero** value and then continue through the coefficient menu until you return to the **Mission Setup Menu**.
4. Repeat the single measurement from the **Self Test Menu,** selection **"D"** to verify that an accurate temperature is now reported.

The Paroscientific Digiquartz™ pressure sensor measurement is accurate to +/- .01% of full scale, assuming that the sensor is mounted vertically with the oil-filled tube at the top. In the PIES, the sensor is mounted horizontally, which introduces a small error. Paroscientific, Inc has assured URI-GSO that the orientation error is a fixed offset that can be corrected by measuring a known pressure with the IES and entering a pressure offset value (Pzero) to make the IES measured value equal the true value. To determine the size of this error, locate the sealed up instrument in an area where the barometric pressure is known. Follow the four steps in the previous paragraph, substituting 'pressure' for 'temperature' and 'Pdif, Pzero' for 'Tdif, Tzero'.

After you have confirmed that the temperature and pressure offsets you have entered result in the correct temperature and pressure measurement values, return to the **Mission Setup Menu** and '**S – SAVE mission configuration'**…

Note: Since the temperature measurement is used to calculate the pressure, be sure to modify the temperature offset <u>first</u>, THEN check the pressure offset.   Remember: orient the IES with transducer UP.

3.7   ACOUSTIC OUTPUT vs. DEPTH CONSIDERATIONS

Unlike the Model 6.1C, the IES Model 6.2 can adjust its acoustic output power over the full deployment depth range without hardware modification… there are no hardware jumpers to change when changing deployment depth. The IES model 6.2 adjusts the output power as a function of depth (entered by the user) using the following formula:

$$\text{Output (dB)} = 170 + (\text{depth(m)} - 500) \times 0.00491$$

The resultant echo and various acoustic levels vs. depth are shown in Figure 3-2.
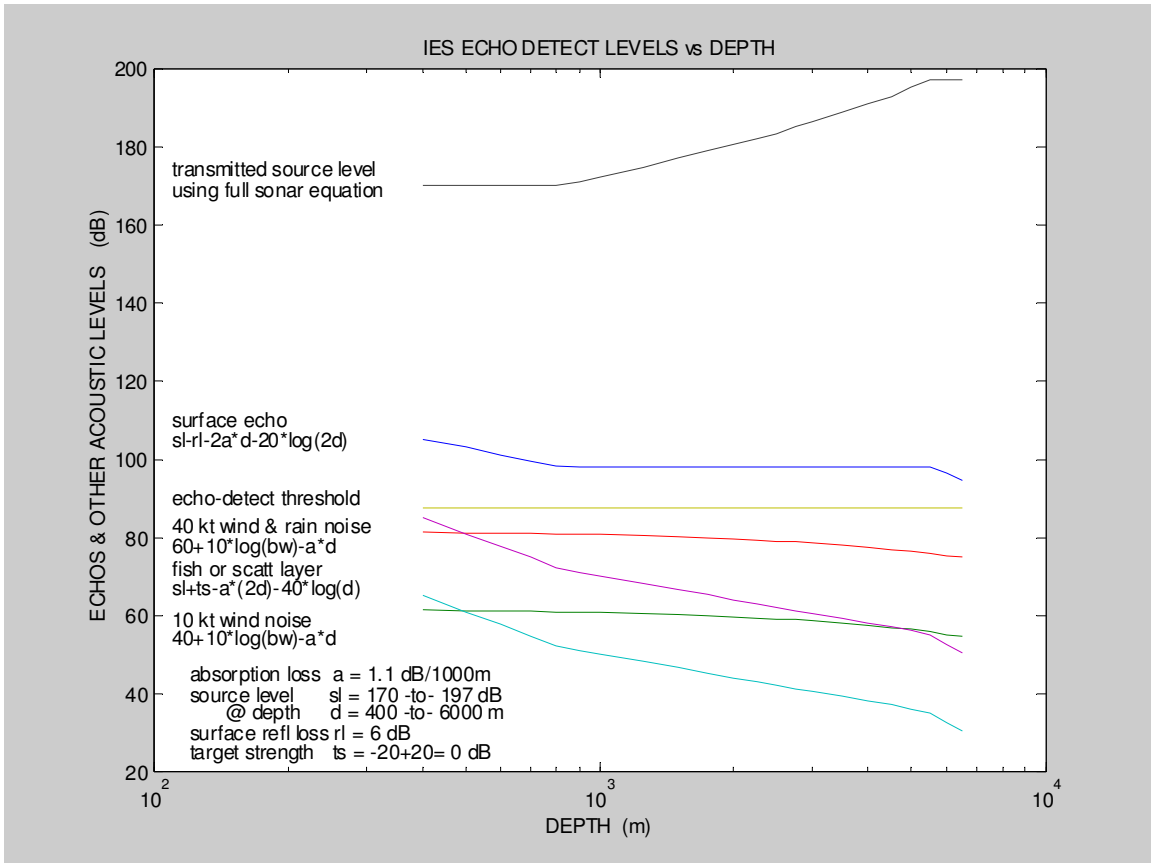
Figure 3-2   Echo and Noise Levels vs. Depth

3.8 SETTING THE AUTO-RELEASE DATE & TIME

The auto-release feature will be activated only if there is no other method to return the IES to the sea surface… either the acoustic command system has failed or the user could not return to (or locate!) the instrument. This emergency back-up feature cannot be disabled *directly*… the user *must* enter some *future* auto-release date and time, otherwise the IES will not start its data acquisition mission. It is felt that, if the acoustic release system has failed or the user cannot return to recover the instrument, the IES can use the last energy in the battery to return to the sea surface and, with luck, be found and returned.

The selection of the auto-release date and time is often difficult because ship availability for such an unplanned event is unpredictable. The best way to select the auto release date and time is to enter the most probable date *after the planned recovery* that a 'rescue' ship may be available. When this date is entered at *IES Setup Menu - selection 'E'*, the IES will calculate (using the existing operating schedule and output power level) the battery capacity required to reach that date. If it is impossible to install the required battery capacity calculated by the IES, the auto-release date will have to be modified or the auto-release function disabled as discussed below.

Setting the auto-release date and time further in the future than the installed battery will support *effectively* disables the auto-release function. When the system battery is near depletion, the IES will sense the impending failure and shut down the data acquisition functions, including the auto-release timer. The release battery will support routine (acoustic command system) recovery operations.

> *WARNING: The selection of an auto-release date and time is also influenced by the memory card capacity. Without sufficient data capacity to get to the auto-release date, the IES will not allow a mission to start. See Chapter 4.4 for more details.*

3.9 DEPLOYMENT CHECKLIST

 About an hour before deployment, attach the communications cable to the IES, turn ON the Hyperterminal capture mode and confirm the proper setup and operations as follows:

 A. Turn ON IES and go to **Self-Test Menu**: (at Main Menu, record the IES version date)
   1. View engineering data: (enter '**H**')
     ⇒Clock Battery > 3.0Vdc
     ⇒Release Battery Drain < 1.3mA
     ⇒System Battery Drain   < 50mA
     ⇒Acoustic Driver : any value from 0 - 17 Vdc
     ⇒Release Battery   > 14.3Vdc
     ⇒System Battery > 6.8 Vdc
     ⇒Internal temperature = ambient temp
   2. Travel time test (enter '**B**') - use the 12.0kHz echo box and speaker to simulate echo
   3. Pressure & Temperature test (enter '**D**') - confirm barometric press and room temp
   4. Output power test (enter '**F**') - record power level before deployment
   5. Release Relay test (enter '**J**') - *with acoustic transducer pointing down*, radio & flasher ON for 30 seconds… flasher ON only when dark. **W*ith acoustic transducer pointing up…*** radio and flasher OFF.
 B. Go to **Memory Card Menu**
   1. erase all files (enter '**D**')
 C. Go to **Mission Setup Menu**
   1. set the clock (enter '**A**')
   2. set the travel time measurement schedule (enter '**B**')
   3. set the pressure & temperature measurement schedule (enter '**C**')
   4. set depth and lockout and output power level (enter '**D**')
   5. set auto-release time (enter '**E**') (see Chapter 3.7)
   6. enable/disable the acoustic telemetry data file (enter '**H**')
   7. enable/disable the pressure sensor raw data file (enter '**J**')
   8. enter mission statement (enter '**K**')
   9. review, save and start the mission (enter '**G**')
 D. **Test ACS system** (Fill out the IES deployment sheet, see Appendix E) Remember, any properly framed command will trigger a 2 ping reply @ 1Hz.
   1. XPND - interrogate @ 12.5kHz, reply @ 12.0Hz (tune deck box for 12.0kHz reception)
   2. CLEAR - 2 ping reply then XPND function is disabled.
   3. TELEM - extra pings at end of every burst. Refer to Manual section 10.7 for details.
   4. RELEASE - 2 ping reply then 4 additional pings (all @ 2-sec rate) - then continuous 4 sec pings when the release block anode and cathode are momentarily shorted together.
 E. *Final Preparations before launch:*
   1. **After the release test**, simply RESET the IES by removing and re-installing the red ON/OFF switch.
   2. Listen for the double "ping" that signifies that the IES is ready to be launched, then remove the communications cable and install the yellow communications plug.
   3. Secure the locking rings on the red & yellow cable ends and push them inside the hard hat.
   4. During the remaining time prior to launch, listen/confirm the proper timing of the travel time measurements.
   5. See Chapter 8 for IES launch instructions.

3.9.1   Important Checklist Notes:

- Remember that ACS responses are blocked during TT measurements - be aware of IES time!
- Without a computer attached, an accurate stopwatch/chronometer is a very handy tool to monitor the IES activities. Once the IES clock is set, the acoustic signals will occur at precise times.
- IES responses to ACS commands will be at reduced power until the release relay is latched.
- The IES will NOT START unless it is RESET, power cycled OFF/ON, or you exit the menu mode through the Setup Menu (selection 'G'). Do not simply unplug the communications cable while in menu mode… the instrument will not start.
- If you do a 'SAVE' (selection 'S' in the Setup Menu) and then turn the IES OFF, a new set of data files will be created for your new configuration when your turn the IES back ON. This is an acceptable way of starting an IES mission but you don't get to review the mission configuration before the mission starts.
- Offloading data files is outlined in the Chapter 4.1 - You MUST use Hyperterminal and the YMODEM transfer protocol here.
- When RESET or turned ON, the IES responds as follows: a single ping, followed (15-30sec) by a double ping… if there is no double ping, attach a computer with Hyperterminal, RESET (power cycle OFF/ON) again and check the error messages. ***Without a computer attached, the double ping is the best indication that the mission has started properly.***

Chapter 4   DATA RECOVERY & ANALYSIS

4.1 DATA OFFLOAD TECHNIQUES

Typically, data from a specific mission will be retrieved from the IES memory card as a set of 4 files: 3 data files (with a matching file index… a T file, a P file, an E file)… and a system log file. The system log file captures the system activities during the collection of all data file sets on the memory card. It is easy to select that portion of the system log that applies to the data file set (T,P & E files) of interest. The details follow. (Note: Telemetry and current meter files do not have a file index)

There are two methods of retrieving data from the IES Model 6.2; instrument open and instrument closed, with the second method requiring the standard RS-232 communications cable provided with the instrument. The two techniques are outlined:

- *IES open* - When the instrument is open, the easiest way to retrieve data is to shut the IES OFF and remove the compact flash memory card, insert it into the PCMCIA port adapter provided with each IES and install it into the PCMCIA port of your computer. The data files are then available as MS-DOS formatted files that can be copied, edited, etc. On Microsoft™ Windows systems, the PCMCIA port is a plug-and-play device, so your computer should automatically recognize the memory card when it is plugged in and assign a drive letter to it. Using Windows Explorer, you can then examine and transfer the files to the hard disk directories of your choice. ***Note: never uplug the memory card from your computer without first disabling the PCMCIA port (see your Windows User's Guide for instructions).***

- *IES closed* - When the IES is sealed up, the data can be uploaded through the external RS-232 cable using the IES User Interface Menus and the IES utility program IES.ht (from your IES Users Disk). Hyperterminal™ must be installed on your computer for this utility to run. It is usually bundled with Microsoft™ Windows software in the c:\programfiles\ accessories\communications directory. Install IES.ht and IES.ico in the same directory. Start from the Memory Card Operations Menu and select ***Transfer data files to computer using Hyperterminal.*** The IES will display the current memory card files and prompt the user for the index of the files (see Chapter 4.2.2) to be transferred. Enter the index and press <enter>… the IES will respond by displaying the available files and prompt the user to continue. If you continue, the IES will set itself up in the YMODEM data *send* mode. The user must then click the right mouse button and select ***Receive File.*** A window will open that allows the user to select the destination directory and the transfer protocol… select ***YMODEM.*** The transfer will start and the Hyperterminal™ window will display the status of the transfer and report any errors. The baud rate for the transfer remains at 9600… however, with error-checking overhead, the effective throughput is about 9220 bytes/sec… it will take about 1 hour to offload a 1 year deployment (3.6Mbytes without current meter data).

4.2 MEMORY CARD FILE MANAGEMENT

The IES Model 6.2 data acquisition system stores information on a type ATA Compact Flash memory card. This non-volatile device can be removed from the IES and, with the adapter supplied with the IES shipment, inserted into any IBM compatible computer (PC) equipped with a PCMCIA port. The memory card then appears as a disk drive and the IES data as MS-DOS formatted files. The data are stored as ASCII text in a form (array matrix) ingestible by Matlab or other data-processing tools. A detailed description of the IES Model 6.2 files and record formats follows.

An external drive for compact flash cards is available from MicroTech called **ZiO!**™.   It costs about $40 US and operates with computers running Windows with USB port support. This inexpensive device is more convenient than the PCMCIA card adapter. See ***www.microtechint.com*** for more details.

4.2.1 File Types

There are a maximum of six types of files on an IES Model 6.1 memory card:

- *System Log File* -   This file will include RESET records, OPERATE records, RELEASE record, ABORT record, mission statement, deployment notes and error messages. There is only one system log file on an IES memory card and it is always present.
- *Engineering Data File* - The "E" file includes one engineering meta-data header record and engineering data records. It is always created, regardless of data acquisition schedules.
- *Travel Time Data File* - The "T" file includes one travel time meta-data header record and a travel time data record for each hour of operation. The file is created if travel time measurements are scheduled.
- *Pressure & Temperature Data File* - The "P" file includes one pressure/temperature meta-data header record and a pressure and temperature data record for each hour of operation. The file is created if the pressure and temperature measurements are scheduled.
- *Pressure & Temperature Raw Data File* – This "F" file has the same format as the P&T data file above but the data are unconverted frequency measurements from the Paroscientific pressure sensor. The data value units are both Hertz instead of µPascals and degrees Celsius. This file is created if it is specifically enabled… see Mission Setup Menu, selection 'J'.
- *Telemetry Data File* – This file is created if the telemetry data processing is enabled (see Mission Setup Menu selection 'H'). If enabled, there is only one telemetry data file. A properly equipped surface ship can command the moored IES to transmit this file via the acoustic telemetry link (see Chapter 10 for acoustic telemetry details).

The **system log file** contains records of various lengths and formats with information intended as a diagnostic tool in case of system malfunction. This file is not intended to be used by time-series data processing tools but as a time-stamped record of routine and unusual events. A detailed description of system log records is given below. The system log file contains information that applies to a time period inclusive of *all the data files* on the memory card… no more… no less. In other words, the user cannot partially erase the memory card… it's all or nothing.

Each time a new data file is created the filename index is incremented and a meta-data header record is written, which provides the information required to process the data in the file (see the meta-data record descriptions below). *There is only one meta-data header record per data file and it is always the first record.* The subsequent data records in the file have identical formats, suitable for time-series processing, as described below.

4.2.2 Data File Creation and File Names

The Model 6.2 IES automatically creates and names all files on the compact flash card. The user cannot choose file names.

There will be only one system log file on the memory card. It is a record of the activities of the system since the file was created and is named IES###.log where ### is the instrument serial number assigned by URI-GSO.   Regardless of the number of restarts and RESETs, there will be only one system **log** file.

The number of data files will depend on the number of times the mission configuration has been modified. A new edition of each type of **data** file (as outlined above) will be created whenever a new mission configuration has been saved, i.e., after the user has restarted the IES via the menu mode. To restart the IES without creating a new set of data files, simply RESET the instrument without accessing the menus or RESET while in menu mode, without saving the configuration.

Data files are named E###_XX.dat, T###_XX.dat, P###_XX.dat and F###_XX.dat, for Engineering, Travel Times, Pressure & Temperature and *raw* Pressure & Temperature data respectively, where ### is a 3-digit IES serial number (e.g., 076) and XX is a sequential index number from 1 to 32768.

The data file names will be indexed to indicate the sequence in which the instrument was restarted after a mission configuration was saved. For example, if 076 is the IES serial number,

- The first (since the last card erasure) travel time data file will be named T076_1.dat.
- If the system is stopped and the user saves another mission configuration, a new data file called T076_2.dat will be created when the data acquisition mode is re-started.
- New data will be appended to these most recent files until the next mission configuration save.

In other words, each new *restart via the menu* will create up to four new data files; E###_XX.dat to hold engineering data, T###_XX.dat to hold travel time data, P###_XX.dat to hold pressure and temperature data and F###_XX.dat to hold *raw* pressure and temperature data. The XX indices of the 'E', 'T', 'P' & 'F' files will all be the same after any save/restart.

4.2.3   Data Recording, Day Buffers and the Time Stamp

Each record will be written to the memory card file on a separate line. The records are written in ASCII text. System log records and meta-data records begin with record type ID characters, as described below, to distinguish them from data records. Meta-data records will start with an ID character to distinguish the **type** of data in the file. Data records (other than meta-data records) all start with a time stamp (hours elapsed since 1970/1/1 00:00:00) which is compatible with the time manipulation functions of ANSI standard C programs) and indicate the hour of data collection. All data file records (other than metadata records) are measurement values delimited by a null (space) character as described below.

At the start of a mission, numerical arrays are created in the IES *volatile* memory (RAM) to hold a single day's data. These arrays are referred to as the day buffers. They are initially filled with zeros, which get replaced with measurement values as the day's data acquisition progresses. Each element of the day buffer arrays corresponds to a particular measurement and time of day. Data are saved in the day buffers until the end of the day when data records are composed and written to the memory card. As outlined below, except for the beginning and end of the mission, memory card write operations will occur at the end of every day… actually, after the 23:50 activities, the end of the measurement day.   After the day buffers are moved to the memory card, all the day buffer values are reset to zero and the data collection process is repeated for the next day.

Note: Each row in a day buffer array corresponds to data collected during a single calendar hour, and, at the end of the day, these rows get composed into a data record. If *any* data have been collected during the hour, the entire row (record) will be written to the memory card. Hence, when the mission was started, it is likely that the first row (record) will get only partially filled, i.e., array values corresponding to measurement values in that hour, *before* the IES was started, will be zero. Likewise, at the end of the mission, when the day buffers are written to the memory card in response to the release function being detected, there will likely be some zeros partially filling the last record for time *after* the IES was released. In other words, the first and last data records in any data file will probably have zeros filling some of their fields.

As stated above, the time stamp in a data record represents the number of hours *elapsed* since 1970/1/1 00:00:00 (the first hour of day 1970/1/1 is hour zero). The data in that record are collected some time during the hour indicated. Hence, in the case of travel time and pressure/temperature data, whose measurements are spread over the hour, the actual time of a measurement could be as much as 50 minutes *after* the time stamp in accord with the measurement schedule documented for the mission in the meta-data header record. The meta-data header record, the first record in every data file, contains the information (start time and measurements-per-hour rate) used to determine *precisely* when each measurement was taken.

4.3 RECORD TYPES & FORMATS

In the following outlines,   **###** indicates the IES serial number and XX indicates the file index. Fields [ ], are delimited by ASCII spaces and all data are in physical units (seconds, degrees, etc.) as indicated in the definition of terms. Each record begins with a line-feed character and ends with a carriage return.

4.3.1 System Log File
　　　In the IES system log file (IES###.log) you will find these record formats:
　RES [yyyy/mm/dd] [hh:mm:ss] [reset type]
　OPR [yyyy/mm/dd] [hh:mm:ss] [IES s/n] [Paros s/n] [TTint] [PTint] [lockout] [data file index]
　[mission statement]
　REL [yyyy/mm/dd] [hh:mm:ss] [reserved] [# of pressure adjustments] [# of clock adjustments]
　MISSION ABORTED at [yyyy/mm/dd] [hh:mm:ss] [error message]

Definition of terms:
RES　This RESET record is appended to the system log file every time the IES is powered up or reset. It will indicate the time of reset. If a system log file does not exist at this time, it will be created as IES###.log. Besides the time stamp which indicates the time the RESET occurred, the **[reset type]** is a number that will be added later.

OPR　This record is appended to the system log file when the user exits the menu mode to start the mission data acquisition *and/or* when the instrument is powered up (or RESET) *without* the user going to the menus. If a system log file does not exist at the time, it will be created. Besides the time stamp, which indicates the time the record was composed, the OPR record will indicate all the important operating parameters that apply to the upcoming data file set:

[IES s/n]	**the IES serial number**
[Paros s/n]	**the pressure sensor serial number**
[TTint]	**the time (minutes) between the start of travel time measurement bursts**
[PTint]	**the time (minutes) between pressure and temperature measurements**
[lockout]	**the time (seconds) that echos are blocked from the IES detector after a transmission - entered by the user via the Mission Setup Menu**
[data file index]	**the file index of the data files just created - use this integer number with the time stamp to match a specific set of data files to a time frame.**
[mission statement]	**a single and separate line of text (80 characters max), entered by the user, as a note to the data analyst**

REL　This record will contain the release time stamp. It will be appended to the system log file when the acoustic or auto release function is detected. Besides the time stamp, a reserved field (always zero), the number of pressure and temperature count corrections and the number of clock corrections during the mission is recorded.

MISSION ABORTED　Once per day, at the end of the day's data collection activities, the CF1 computer module checks to see if the IES battery voltage is too low or the system current is too high to support further activities. In either case, if a problem is detected, this message is written to the system log file, subsequent data collection activities are suspended and the system will enter a low power state. The **[error message]** will indicate whether low voltage or high current is the problem. This activity does not affect the acoustic command system… the IES will still be listening, waiting for acoustic commands. However, the auto-release function will no longer be enabled.

Example:
```
OPR 1999/12/20 14:40:43 002 77523 10 10 1.20 0
Okinawa – Frontier Project: Alpha – Site B3 – depth 2350 m
RES 1999/12/20 18:42:40 0
RES 1999/12/21 10:26:05 0
REL 1999/12/27 09:00:13 0 0 5
RES 1999/12/27 09:01:22 0
```

Example Notes:
　　　➢　The system log file does not have to start with a RES record… the memory card may have been erased just prior to starting the mission.

4.3.2 Engineering Data File

The engineering data file (E###_XX.dat) begins with this meta-data record:

   E [yyyy/mm/dd] [hh:mm:ss] [IES s/n]

and is followed by these engineering data records:

   [hour] [ClkVbat] [Irel] [Isys] [RelVbat] [SysVbat] [IntPress] IntTemp] [TTav] [Pav] [Tav] [Pfrq] [Tfrq] [ClkfrqDiff]

Definition of terms:

E   The engineering meta-data record is the first record of the engineering data file. Besides the time stamp, the IES instrument serial number **[IES s/n]** is reported.   An engineering meta-data record will be composed and written to memory card each time a new engineering data file is created… it will always be the first record in the E###_XX.dat file.

The engineering data record will contain a time stamp and a number of IES self-test measurements made to monitor the instrument's operations. An engineering data record will be composed and written to the memory card at the end of each day's operations, i.e., just *after* the activities that started at 23:50:00.

[hour]	**the number of hours elapsed since 1970/1/1**
[ClkVbat]	**the IES real time clock backup battery voltage, in Volts**
[Irel]	**the release battery current drain, in milliAmperes**
[Isys]	**the system battery current drain, in milliAmperes**
[RelVbat]	**the release battery voltage, in Volts**
[SysVbat]	**the system battery voltage, in Volts**
[IntPress]	**the internal pressure (vacuum), in psia (NOT INSTALLED)**
[IntTemp]	**the internal temperature, in degrees C**
[TTav]	**the average travel time for the previous day, in units of 10^{-5} second**
[Pav]	**the average pressure for the previous day, in units of 10 μPa**
[Tav]	**the average temperature for the previous day, in units of 10^{-4} degree C**
[Pfrq]	**the last pressure sensor raw data value, in Hertz**
[Tfrq]	**the last temperature sensor raw data value, in Hertz**
[ClkfrqDiff]	**the error, from 32768Hz, of the IES clock crystal, in Hertz**

Example:
```
E 2001/11/21 12:48:26 039
279551 3.06 0.84 38.02 14.19 6.93 0.20 4.16 8.7113 10074 5222 33025.691 171162.844 −0.238
279575 3.07 0.86 38.04 14.18 6.92 0.20 3.65 8.7114 10285 0 33025.504 171160.109 −0.271
279599 3.07 0.84 37.98 14.18 6.90 0.19 3.48 8.7114 10384 0 33025.574 171160.469 −0.270
279623 3.08 0.74 38.01 14.16 6.91 0.19 3.51 8.7114 10439 0 33025.637 171160.984 −0.270
279647 3.06 0.79 38.04 14.18 6.90 0.20 3.74 8.7114 10415 0 33025.609 171161.109 −0.262
```

Example Notes:
- ➢ The [hour] value on the first engineering *data* record corresponds to the 23rd hour of the first day of data collection. It **may or may not** be the 23rd hour of the date in the meta-data record because the IES may have been turned OFF **after** the mission was started but **before** any data were collected… and then turned ON, days, even months later! Looking at the time stamps of the RES records in the system log file should help to reconstruct the ON/OFF time line of the IES.
- ➢ The [hour] stamp in the engineering data records increments by 24 hours.

4.3.3 Travel Time Data File

The travel time data file (T###_XX.dat) will begin with this meta-data record:
  T [yyyy/mm/dd] [hh:mm:ss] [IES s/n] [TTint]
and is followed by these data records:
  [hour] [TT1] [TT2]…… [TT24]

Definition of terms:
T The 'T' record is the first record of the travel time file. Besides the time stamp… in calendar format, it contains **[IES s/n],** the IES instrument serial number and the travel time burst measurement interval, **[TTint]**, in minutes.   A travel time meta-data record will be composed and written to the memory card each time a new travel time data file is created… it will always be the first record in the T###_XX.dat file.

  The travel time data file is composed of a time stamp followed by the 24 travel time measurements that were taken during that hour. Travel time data are saved in a day buffer until the end of the last daily measurement activities, at which time they will be appended to the active T###_XX.dat file on the memory card.

[hour]   the number of hours elapsed since 0 hours 1970/1/1
[TT1] - [TT24] the 24 travel times measured during the indicated hour, in units of 10^{-5} second

Example:
```
T 2001/11/21 12:48:26 039 10
279540 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 999999 999999 999999 871001
279541 871022 871010 871123 870998 871016 871038 871022 871007 871007 871001 871108 871007
       871053 871032 871087 871035 871084 871078 871056 871035 871050 871038 871038 871047
279542 871053 871062 871047 871081 871050 871044 871090 871065 871056 871065 871078 871059
       871078 871078 871065 871084 871087 871087 871084 871090 871105 871102 871099 871102
279543 871123 871111 871117 871114 871117 871117 999999 871114 871117 871111 871114 871117
       871114 871114 871111 871126 871123 871126 871102 871099 871111 871117 871117 871114
279544 871117 871132 871129 871132 871117 871129 871114 871120 871111 871114 871114 871114
       871111 871126 871126 871126 871132 871114 871132 871129 871126 871120 871111 871126
279545 871120 871132 871120 871114 871129 871132 871126 871111 871126 871126 871129 871114
       871126 871108 871123 871108 871142 871129 871129 871136 871123 871117 871126 871132
279546 871126 871117 871120 871120 871136 871129 871145 871123 871132 871129 871129 871132
       871126 871123 871126 871117 871142 871132 871129 871142 871126 871132 871129 871120
```

Example Notes:
  ➢ The rows of data are wrapped to fit this page. In fact, each record (row) begins with an hour number (e.g., 279541), has 24 travel times (representing an hour of data collection) and ends with a carriage return. The zeros, in the example, represent travel time measurements not taken and the 999999 represent measurements attempted but no echo was detected.
  ➢ The [hour] value on the first travel time data record corresponds to the first hour of data collection. However, it **may or may not** be an hour of the day stamped in the meta-data 'T' record because the IES may have been turned OFF **after** the mission was started (and the data files and meta-records were created) but **before** any data were actually collected. Looking at the time stamps of the OPR and RES records in the system log file should help to reconstruct the ON/OFF time line of the IES.

4.3.4 Pressure and Temperature Data File

The pressure and temperature data file (P###_XX.dat) will begin with this meta-data record:
   P [yyyy/mm/dd] [hh:mm:ss] [IES s/n] [Paros s/n] [PTint] [Paros coefficients]
and is followed by these pressure and temperature data records:
   [hour] [P1] [T1] [P2] [T2]……… [P6] [T6]

Definition of terms:
P   This record is the first record of the pressure and temperature data file and contains a time stamp… in
       calendar format, the IES instrument serial number **[IES s/n]**, the Paros serial number **[Paros s/n]**, the
       pressure and temperature measurement interval **[PTint]**, in minutes.

[Paros coefficients] A list of the fourteen Paroscientific pressure sensor conversion coefficients, in this
       order: U_0, Y_1, Y_2, Y_3, C_1, C_2, C_3, D_1, D_2, T_1, T_2, T_3, T_4, T_5 , T_{zero}, P_{zero}.   Refer to Chapter 3.5 and
       Appendix B to see how these coefficients are applied (by the IES) to calculate actual pressure and
       temperature.

A pressure/temperature meta-data header record will be composed and written to the memory card each
       time a new pressure data file is created… it will always be the first record in the P###_XX.dat file.

The pressure and temperature data record is composed of the time stamp and the pressure and temperature
       measurement pairs acquired during that hour. Some of the measurement pairs may be zeros depending
       on the pressure and temperature measurement schedule. There is space allocated for 6 measurement
       pairs per hour (measurements every ten minutes), so if, for example, the schedule only calls for one
       P&T measurement/hour, there will be 5 pairs of zeros in the record (see Example 2 below).   The
       measurement pairs are delimited by two nulls (spaces) as shown. Pressure/temperature data are saved in
       a day buffer until the end of the last daily measurement activities at which time they will be appended to
       the active P###_XX.dat file on the memory card.

[hour]   the number of hours elapsed since 0 hours 1970/1/1
[P1] [T1]… [P6] [T6] pressure and temperature measurement pairs in units of 10Pa (1/10millibar)
                           and 10^{-4} degree C respectively.
Example 1:
```
P 2001/11/21 12:48:26 039 87087 10 5.842375 −4036.615 −2110.00 0.00 −47948.39 3713.318
162670.80 0.037720 0.00 30.28409 2.333273 60.53492 71.7080 0.00 0.00 0.00
279540 0 0   0 0   0 0   0 0   0 0   10982 19447
279541 10863 19479   10732 19420   10519 19220   10244 18838   9990 18260   9755 17504
279542 9569 16586   9450 15557   9397 14463   9386 13365   9417 12294   9473 11272
279543 9532 10318   9593 9436   9659 8626   9717 7883   9763 7210   9810 6604
279544 9854 6048   9890 5546   9928 5093   9956 4677   9980 4305   10013 3958
279545 10029 3647   10048 3363   10063 3105   10076 2865   10094 2643   10104 2442
279546 10114 2259   10125 2089   10130 1930   10134 1787   10141 1652   10153 1526
279547 10164 1412   10167 1304   10178 1203   10180 1110   10179 1023   10181 944
279548 10189 867   10194 795   10198 727   10201 667   10209 607   10203 555
279549 10209 503   10209 452   10209 412   10214 367   10221 325   10217 288
279550 10225 251   10219 216   10228 185   10226 156   10227 129   10231 102
279551 10229 77   10236 52   10233 30   10232 11   10236 −11   10239 −27
279552 10243 −50   10237 −66   10242 −83   10243 −100   10241 −112   10246 −129
279553 10244 −141   10239 −151   10242 −166   10241 −176   10247 −188   10248 −201
279554 10243 −211   10241 −222   10240 −228   10248 −242   10252 −252   10254 −259
279555 10244 −265   10248 −275   10244 −279   10248 −288   10250 −296   10254 −300
279556 10247 −308   10252 −312   10253 −315   10260 −321   10257 −325   10259 −327
```

Example 1 Notes:
       ➢   The meta-data header record is wrapped to fit this page… the data records are not wrapped.
       ➢   Each data record (row) begins with an hour number (e.g., 279540), has up to 6 pairs
            (depending on P&T schedule) of pressure and temperature measurements and ends with a
            carriage return. The zeros, in the example, represent pressure measurements not taken.
       ➢   This example shows measurements taken every ten minutes. If a P&T measurement were
            taken every 30 minutes, it would look like example 2 that follows.

4.3.4 Pressure and Temperature Data File (cont'd)

Example 2:
```
P 2001/11/21 12:48:26 039 87087 10 5.842375 –4036.615 –2110.00 0.00 –47948.39 3713.318
162670.80 0.037720 0.00 30.28409 2.333273 60.53492 71.7080 0.00 0.00 0.00
279540 0 0  0 0  0 0  0 0  0 0  10982 19447
279541 10863 19479  0 0  0 0  10244 18838  0 0  0 0
279542 9569 16586  0 0  0 0  9386 13365  0 0  0 0
279543 9532 10318  0 0  0 0  9717 7883  0 0  0 0
279544 9854 6048  0 0  0 0  9956 4677  0 0  0 0
279545 10029 3647  0 0  0 0  10076 2865  0 0  0 0
279546 10114 2259  0 0  0 0  10134 1787  0 0  0 0
279547 10164 1412  0 0  0 0  10180 1110  0 0  0 0
279548 10189 867  0 0  0 0  10201 667  0 0  0 0
279549 10209 503  0 0  0 0  10214 367  0 0  0 0
279550 10225 251  0 0  0 0  10226 156  0 0  0 0
```

Example 1 & 2 Notes:
- ➢ In example 2, measurements were taken on the hour and at 30 minutes after the hour. The zeros in the record signify that measurements were *not* taken at the 10, 20, 40 and 50 minute wake-up times. The zeros will be ignored in the data processing and these data will be processed as a time series of measurements taken 30 minutes apart.
- ➢ In both examples, the [hour] value on the first travel time data record corresponds to the first hour of data collection. However, it **may or may not** be an hour of the day stamped in the meta-data 'T' record because the IES may have been turned OFF **after** the mission was started (and the data files were created) but **before** any data were collected… days or months later! Looking at the time stamps of the OPR and RES records in the system log file should help to reconstruct the ON/OFF time line of the IES.

4.3.5   Pressure and Temperature Raw Data File

The pressure and temperature raw data 'F' file is identical in format to that of the 'P' file described above… the meta-data record is the same (except it has an 'F' instead of a 'P' as the first character) and the relationship of the measurements to the time stamp is the same. The only difference is in the units of the data… the 'P' file pressure and temperature measurement pairs are in units of 10μPa (1/10millibar)and 10^{-4} degree C respectively and the 'F' file measurements are in units of 10^{-3}Hertz. See Example 1.

Example 1:
```
F 2001/11/21 12:48:26 039 87087 10 5.842375 –4036.615 –2110.00 0.00 –47948.39 3713.318
162670.80 0.037720 0.00 30.28409 2.333273 60.53492 71.7080 0.00 0.00 0.00
279540 0 0  0 0  0 0  0 0  0 0  33036868 171304816
279541 33036824 171305040  33036730 171304608  33036528 171303136  33036204 171300336
       33035790 171296080  33035296 171290512
279542 33034742 171283776  33034156 171276224  33033562 171268224  33032980 171260176
       33032426 171252336  33031898 171244880
279543 33031406 171237904  33030950 171231472  33030528 171225568  33030136 171220176
       33029778 171215280  33029454 171210864
279544 33029152 171206832  33028878 171203184  33028632 171199888  33028402 171196880
       33028196 171194176  33028004 171191664
279545 33027828 171189424  33027668 171187360  33027520 171185488  33027382 171183744
       33027258 171182160  33027140 171180704
279546 33027036 171179376  33026938 171178144  33026844 171176992  33026758 171175952
       33026680 171174992  33026610 171174080
```

Example 1 Notes:
- ➢ The meta-data header record and data records are wrapped to fit this page.
- ➢ Measurements were taken every ten minutes.

4.3.6 Telemetry Data File

The telemetry data file (TELEM.dat) will begin with these two meta-data records:

   TEL [yyyy/mm/dd] [hh:mm:ss] [IES s/n]
   375 0 0

and is followed by these travel time and pressure data records:

  [year-day] [T] [P]   : for IES with pressure sensor
  [year-day] [T] [P] [S] [H]   : for IES with pressure & Doppler current sensor

 The data are low-pass filtered using a tide-elimination filter [Godin, 1972, Sections 2.1.1 and 4.5].
 Reference: Godin, G., The Analysis of Tides, University of Toronto Press, 1972

Definition of terms:

[year-day]	**the year–day, an integer from 1 to 365 (or 366 on a leap year)**
[375 0 0]	**a pseudo record that flags the beginning of the data (see below)**
[T]	**processed travel time data, in units of seconds**
[P]	**processed pressure data, in units of 10μPa**
[S]	**processed current speed, in cm/sec**
[H]	**current heading, compass angle, in degrees, increasing clockwise from North**

Example:

```
TEL 1999/12/20 14:40:43 039
375 0 0
234 3.3768 2532675
235 3.3768 2532675
236 3.3769 2532676
237 3.3769 2532676
238 3.3770 2532677
239 3.3770 2532677
```

Telemetry File Notes:

➢ The time that should be assigned to a pair of data values is 12:00:00 of the specified year day. The time interval is one day.

➢ Before the detiding processing can begin the IES must collect 72 hourly mean values for travel time and pressure. The IES will run the detide program at the end (midnight) of every day beginning *after* the 72 hour data buffer has been filled. In other words, it will not start processing data for the telemetry until the fourth midnight (by the IES clock) of the mission… the first partial day's data will not be processed. The telemetry file (with the TEL meta-data record) will be created at the start of the mission, but there will be no processed data until the fourth midnight.

➢ Only one meta-data record is written to the telemetry file. Each time a new mission starts the 72 hour buffer is cleared and must be refilled… hence restarts will cause a 3 day gap in the time stamp.

➢ The acoustic telemetry process will read the file backwards (LIFO: last-in-first-out) and the first record [375 0 0] will provide a flag to the receiver that the end of the file has been reached.

 Note: See Chapter 10 & 11 for a complete description of the acoustic telemetry feature and additional information on telemetry files.

Chapter 5   ACOUSTIC COMMAND SUBSYSTEM (ACS)

The Acoustic Command Subsystem (ACS) of the Model 6.2 IES is a block of circuitry on the IES board that is dedicated to receiving acoustic commands from a surface ship and converting those commands into control functions used to:

- locate a deployed IES
- release it from the sea floor
- provide acoustic tracking signals during recovery operations.
- initiate the data telemetry function

This chapter describes the ACS and provides instructions on 1) how to set up the ACS on an individual IES and 2) how to set up the deck box, either the EdgeTech™ Model 8011A or the Benthos™ Model DS-7000.   Chapter 8 describes how to *use* the ACS during deployment and recovery operations.

The ACS has been designed to decode bit-encoded commands like those produced by the Model 8011A deck box manufactured by EdgeTech Inc (formally EG&G Instruments). The standard Model DS-7000, manufactured by Benthos, Inc. of Falmouth, MA, USA can be customized to transmit all of the IES/ACS codes… contact Benthos for details and cost.

The ACS can be configured (via hardware switches/jumpers) to accept *one each* of the following code sets: 4 transpond enable codes, 4 telemetry enable codes, 4 beacon enable codes and 64 release codes. A fifth command (CLEAR) was created by allowing *any properly framed* command (regardless of whether it is a valid command for the instrument) to cancel a previous telemetry or transpond command. A special command has been designated as the CLEAR command for *all* IESs… see the following sections for details.

In general, the acoustic command circuits in the IES Model 6.2 are independent of the data acquisition circuits and are additionally powered by a separate battery. There are, however, some components that are shared by the two subsystems… namely the output driver, transformer and acoustic transducer. The release battery will power these components, powered by the system battery during routine data acquisition functions, *after* the release has been activated *or* if the system battery fails.

5.1 PROGRAMMING THE ACOUSTIC COMMANDS

The jumpers JP1 thru JP4 on the IES circuit board are used to encode the acoustic command signals for a specific instrument.   After selecting the desired command number, use the switches/jumpers to set the binary value of the command according to the weights given in Table 5-1. See the following section for an example.

JUMPER	FUNCTION	WEIGHT
JP4-1 to JP4-4	telem	1
JP4-2 to JP4-3	telem	2
JP3-1 to JP3-4	xpnd	1
JP3-2 to JP3-3	xpnd	2
JP2-1 to JP2-4	beacon	1
JP2-2 to JP2-3	beacon	2
JP1-1 to JP1-12	release	1
JP1-2 to JP1-11	release	2
JP1-3 to JP1-10	release	4
JP1-4 to JP1-9	release	8
JP1-5 to JP1-8	release	16
JP1-6 to JP1-7	release	32

Table 5-1   IES circuit board jumper weights - used to encode the command number

After the four commands are encoded on an individual IES, the corresponding equivalents must be entered into the deck box sending unit as shown in Table 5-2: (see the following sections for examples of setting up either type of deck box, EdgeTech or Benthos)

TELEM CODE	EdgTech 8011A code	Benthos DS-7000 URI code
0	1 1000 0100 0 1 0100 0100 0	64
1	1 1100 0100 0 1 0010 0100 0	65
2	1 1010 0100 0 1 0110 0100 0	66
3	1 1110 0100 0 1 0001 0100 0	67

XPND CODE

0	1 1000 1000 0 1 0100 1000 0	68
1	1 1100 1000 0 1 0010 1000 0	69
2	1 1010 1000 0 1 0110 1000 0	70
3	1 1110 1000 0 1 0001 1000 0	71

BEACON CODE

0	1 1000 0000 0 1 0100 0000 0	72
1	1 1100 0000 0 1 0010 0000 0	73
2	1 1010 0000 0 1 0110 0000 0	74
3	1 1110 0000 0 1 0001 0000 0	75

CLEAR CODE

	1 0000 0000 0 1 1111 1111 0	76	**<= VALID FOR ALL IESs**

Figure 5-2 Deck box settings for various IES commands
(continued on next page)

RELEASE CODES	EdgeTech 8011A codes	Benthos DS-7000 codes
0	1 0000 1100 0 1 1000 1100 0	0
1	1 0100 1100 0 1 1100 1100 0	1
2	1 0010 1100 0 1 1010 1100 0	2
3	1 0110 1100 0 1 1110 1100 0	3
4	1 0001 1100 0 1 1001 1100 0	4
5	1 0101 1100 0 1 1101 1100 0	5
6	1 0011 1100 0 1 1011 1100 0	6
7	1 0111 1100 0 1 1111 1100 0	7
8	1 0000 0010 0 1 1000 0010 0	8
9	1 0100 0010 0 1 1100 0010 0	9
10	1 0010 0010 0 1 1010 0010 0	10
11	1 0110 0010 0 1 1110 0010 0	11
12	1 0001 0010 0 1 1001 0010 0	12
13	1 0101 0010 0 1 1101 0010 0	13
14	1 0011 0010 0 1 1011 0010 0	14
15	1 0111 0010 0 1 1111 0010 0	15
16	1 0000 1010 0 1 1000 1010 0	16
17	1 0100 1010 0 1 1100 1010 0	17
18	1 0010 1010 0 1 1010 1010 0	18
19	1 0110 1010 0 1 1110 1010 0	19
20	1 0001 1010 0 1 1001 1010 0	20
21	1 0101 1010 0 1 1101 1010 0	21
22	1 0011 1010 0 1 1011 1010 0	22
23	1 0111 1010 0 1 1111 1010 0	23
24	1 0000 0110 0 1 1000 0110 0	24
25	1 0100 0110 0 1 1100 0110 0	25
26	1 0010 0110 0 1 1010 0110 0	26
27	1 0110 0110 0 1 1110 0110 0	27
28	1 0001 0110 0 1 1001 0110 0	28
29	1 0101 0110 0 1 1101 0110 0	29
30	1 0011 0110 0 1 1011 0110 0	30
31	1 0111 0110 0 1 1111 0110 0	31
32	1 0000 1110 0 1 1000 1110 0	32
33	1 0100 1110 0 1 1100 1110 0	33
34	1 0010 1110 0 1 1010 1110 0	34
35	1 0110 1110 0 1 1110 1110 0	35
36	1 0001 1110 0 1 1001 1110 0	36
37	1 0101 1110 0 1 1101 1110 0	37
38	1 0011 1110 0 1 1011 1110 0	38
39	1 0111 1110 0 1 1111 1110 0	39
40	1 0000 0001 0 1 1000 0001 0	40
41	1 0100 0001 0 1 1100 0001 0	41
42	1 0010 0001 0 1 1010 0001 0	42
43	1 0110 0001 0 1 1110 0001 0	43
44	1 0001 0001 0 1 1001 0001 0	44
45	1 0101 0001 0 1 1101 0001 0	45
46	1 0011 0001 0 1 1011 0001 0	46
47	1 0111 0001 0 1 1111 0001 0	47
48	1 0000 1001 0 1 1000 1001 0	48
49	1 0100 1001 0 1 1100 1001 0	49
50	1 0010 1001 0 1 1010 1001 0	50
51	1 0110 1001 0 1 1110 1001 0	51
52	1 0001 1001 0 1 1001 1001 0	52
53	1 0101 1001 0 1 1101 1001 0	53
54	1 0011 1001 0 1 1011 1001 0	54
55	1 0111 1001 0 1 1111 1001 0	55
56	1 0000 0101 0 1 1000 0101 0	56
57	1 0100 0101 0 1 1100 0101 0	57
58	1 0010 0101 0 1 1010 0101 0	58
59	1 0110 0101 0 1 1110 0101 0	59
60	1 0001 0101 0 1 1001 0101 0	60
61	1 0101 0101 0 1 1101 0101 0	61
62	1 0011 0101 0 1 1011 0101 0	62
63	1 0111 0101 0 1 1111 0101 0	63

Figure 5-2 (continued)

5.2 ACOUSTIC COMMAND ENCODING EXAMPLE

        The acoustic commands for each IES are encoded and tested at the time of manufacture. However, the user has the option to modify an IES ACS system (change the jumpers on the circuit board – see Figure 2-1) so that the instrument will not detect codes intended for IESs at nearby deployment sites… especially the release command!

        The following example outlines how to set up the IES and either the EdgeTech 8011A or the Benthos DS-7000 deck box for a set of codes.

        Assume the user has chosen the following ACS commands for a particular IES:

- TELEMETRY   CODE # 1
- TRANSPOND   CODE # 2
- BEACON   CODE # 3
- RELEASE   CODE # 52

        First, code the IES circuit board (Figure 2-1) using the weights in Table 5-1 to set the hexadecimal values of each chosen command… the proper settings on JP1 thru JP4 are:

command code #:	1	2	3	52
jumper installed(0=NO, 1=YES):	01	10	11	110100
circuit board reference:	JP4	JP3	JP2	JP1
circuit board label:	TELEM	XPND	BEACON	RELEASE

        After programming these commands onto the IES circuit board, the corresponding binary equivalents from the tables above must be encoded into the acoustic command deck box… follow these steps for the appropriate deck unit:

EdgeTech 8011A Deck Box Setup

- Go to Command Setup < menu >
- Choose Custom Cmd Setup < 2 >
- Choose a custom command number < 0 - 9 >
- Choose a Bit-encoded Custom Command < 1 >
- Set 0-freq = 12500 Hz
- Set 1-freq = 12000 Hz
- Set Bit ON time = 22 msec
- Set OFF time = 228 msec, <enter>
- Enter the 20 bit binary code, from Table 5-2, using 0 & 1 keys, <enter>
- Choose guarded for RELEASE command, not-guarded for others
- Return to Command mode and enter the custom cmd# (0-9)
- Set the output level and use <enter> again to send the command
- Set the deck box *receive* frequency at 12.00kHz

        For our example, the binary codes entered in the deck box are:

TELEM (1)	Custom command #1	=>	1 1100 0100 0 1 0010 0100 0
XPND (2)	Custom command #2	=>	1 1010 1000 0 1 0110 1000 0
BEACON (3)	Custom command #3	=>	1 1110 0000 0 1 0001 0000 0
RELEASE(52)	Custom command #4	=>	1 0001 1001 0 1 1001 1001 0

        IMPORTANT: Allow at least 15 seconds between command transmissions.

Recommendation: Attach a label to the display of the deck box that matches the custom command number with its IES serial number and command function.

Benthos DS-7000 Deck Box Setup

- press POWER and verify that the display shows:

  BENTHOS DS7000

  ES 7331   A-500-114   V1.41

  (only deck sets with these firmware codes will work with URI IES units)
- Set the RX FREQ @ 12.0 kHz
- press MODE SELECT until "ID / URI " is in AUX 3 display window
- press AUX 2 scroll arrows until the desired URI code is displayed (see Table 5-2)
- press SEND COMMAND + SINGLE to transmit the URI/IES command

For our example, the codes entered in the AUX 2 window of the deck box are:

TELEM (1)	AUX ## 2 => 65
XPND (2)	AUX ## 2 => 70
BEACON (3)	AUX ## 2 => 75
RELEASE(52)	AUX ## 2 => 52
CLEAR	AUX ## 2 => 76

IMPORTANT: Allow at least 15 seconds between command transmissions.

Recommendation: Attach a label to the display of the deck box that matches the URI/ID command number with its IES serial number and command function.

5.3   ACOUSTIC COMMAND DETAILS

IMPORTANT*: Responses from the acoustic command subsystem are blocked during travel time measurements so the user must be aware of the measurement schedule when using acoustic commands. To prevent the ACS system from being left in an active state (XPND or TELEM ON), the CF1 computer will reset the ACS controller every midnight (according to the IES clock)… this disables all ACS functions.*

Transpond Enable (XPND)

This command sets the acoustic command subsystem in the transpond mode. When the command is accepted the system will reply with two 12.0 kHz pulses, two seconds apart. The command decoder will then continuously listen for 12.5kHz interrogation pulses and, if detected, will respond immediately with a 12.0kHz reply pulse. After each transpond reply, the system will wait for 4 seconds before returning to listening so the shortest recommended interrogation interval is 6 seconds. The system will continue in the transpond mode until it has been disabled by a CLEAR command (see below) or a reset. During travel time sampling, the transpond replies will be blocked by the data acquisition function. While in the transpond mode the system *can* receive the release command.

Telemetry Enable (TELEM)

This command sets the IES data acquisition subsystem in the pulse delay telemetry (PDT telemetry) mode. When the command is accepted, the system will reply with two 12.0 kHz pulses, two seconds apart. After the next measurement burst is complete, the IES will begin transmission of either *burst* telemetry or *file* telemetry, depending on how long it has been since the mission was started. The *many important* details of this operation are outlined in Chapter 10. The PDT telemetry is used to verify the proper functioning of the IES measurement circuits and to collect data in lieu of recovering the IES. The system will remain in this mode until disabled by the CLEAR command (see below), the file telemetry is complete, or a reset. While in the TELEM mode, the system *can* receive the release command.

CLEAR (Disable Transpond & Telemetry)

This command will disable the Transpond and Telemetry modes if either is enabled. In fact, any command, if properly framed (bits 1 & 11 are 1's, bits 10 & 20 are 0's) will act as a disable command. When the command is accepted, the system will reply with two 12.0 kHz pulses, 2 seconds apart. *It is important to remember that the Transpond and Telemetry modes cannot be enabled simultaneously, since the reception of either command disables the other. If either of these commands is enabled at midnight (according to the IES clock), it will be disabled.*

Beacon Enable (BEACON)

This command sets the acoustic command subsystem in the beacon mode. When the command is accepted the system will reply with two 12.0 kHz pulses, two seconds apart. The command decoder will then generate 12.0 kHz pulses at an eight second rate for the next twenty minutes unless disabled by a reset. During this time the decoder will not accept any other commands… so the beacon cannot be terminated by the CLEAR command. During a travel time measurement burst the beacon is blocked, but will continue after the burst if twenty minutes has not passed since the beacon was enabled. While in beacon mode the system *cannot* receive a release command. After the twenty minutes of beacon mode have expired the acoustic command subsystem will return to listening for further commands.

Note: If the Beacon function is enabled at midnight (according to the IES clock), it will be disabled.

RELEASE

This command sets the IES in release mode. When the command is accepted the system will reply with six 12.0 kHz pulses, two seconds apart to signify that a release command has been detected. If current is detected in the burn-wire release, the system will continue to transmit pulses at a four second rate for at least 3 hours. The burn wire release will usually take about 15-20 minutes before it drops the ballast anchor, allowing the IES to come to the surface.

IMPORTANT: Refer to Chapter 8 for details of at-sea operations regarding the release function.

The IES data acquisition subsystem will not detect the release activation *until the next ten-minute wakeup*. When the IES data acquisition subsystem detects the active release, it performs the following tasks:

- Writes the release time in the system log
- Moves all data in the day buffers to the memory card
- Writes an engineering data record to the memory card
- Stops the data acquisition schedule and returns to listening mode

---

WARNING: When performing short tests in the lab it is important to remember that, after an acoustic (ACS) release, the IES does not transfer the data to the memory card until the NEXT ten minute wakeup. If, during testing on the lab bench, you RESET to the menu mode after an ACS release, without waiting for the data to be transferred, you will lose the data from that day that have been temporarily stored in RAM memory. If you don't activate the release but you want to transfer the data from a short test to the memory card, connect your PC, wait for the next ten minute wake up, establish communications with the IES, go to the Memory Card Operations Menu (see Chapter 2.3.4) and select 'F'- Save RAM data to Memory Card… the data buffers will then be appended to the existing data files.

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Chapter 6   CIRCUIT DETAILS

6.1   BATTERY PACK

Refer to Figure 6-1 for a diagram of the IES Model 6.2 17" Lithium battery pack. The battery cells are mounted on a reusable circuit board and are divided into two independent sections… the lower section is for the acoustic command subsystem (referred to as the release battery) and the upper section is for the IES data acquisition subsystem (referred to as the system battery) – see Figure 1-1. [Note: Cells # B23 & B24 are on the lower section and are part of the system battery].

The board is configured for size "DD" lithium cells (with tab or pigtail terminals and open circuit voltage = 3.6Volt). If the full complement of batteries is not needed, be sure to load the cells in such a way that the spatial symmetry of the pack is maintained, i.e., balanced around the center, otherwise the IES may sit at an angle during deployment. The board is designed to accommodate symmetric packs of 120, 180 and 240 Ampere-hours for the system battery… the release battery will always have 8 cells in a symmetric arrangement.

As the diagram shows, parallel diodes on each release battery cell prevent an individual cell failure from influencing the entire stack other than lowering the voltage by 3.6V.

The IES Lithium cells, unlike carbon or alkaline cells, maintain their open-circuit voltage (3.4 – 3.6 Volts) until near end-of-life, so it is not possible to determine the energy remaining in a cell with a voltage measurement. Use the chart in Chapter 3.3 to estimate how long a battery will last.

NOTE: *In case of battery failure, the system battery will attempt to assist the release battery but not vice versa.*
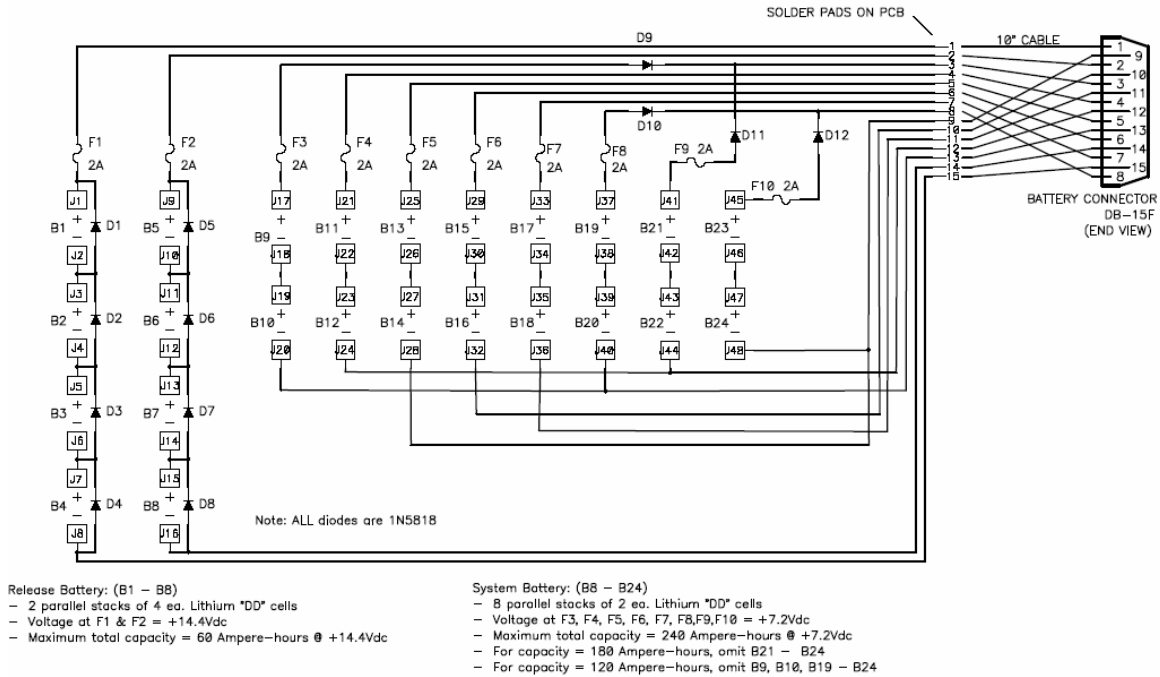

Figure 6-1   IES Model 6.2 Lithium Battery Pack for 17" Sphere

6.2 PERSISTOR COMPUTER MODULE & MEMORY CARD

All scheduling, measurement, data processing and storage functions of the Model 6.2 IES are controlled by the Persistor CF1 computer module, manufactured by Peripheral Issues, Inc. of Falmouth, MA, USA. See their web site at www.persistor.com . The data file management and memory card subsystems are integral parts of the CF1module. The CF1 mounts on the IES circuit board with a simple connector so that any problems traceable to the computer module can be resolved with a CF1 module replacement.

6.3 RECOVERY AIDS (the RELOC Module)

In addition to the acoustic command subsystem, which controls the mechanical release mechanism and the relocation and recovery acoustic signals, there is an optional radio/flasher module (RELOC) which mounts inside the glass sphere to aid in recovery *after* the IES has reached the surface. The RELOC module contains a high intensity (1 million candlepower) xenon flasher (flash at ~ 1Hz) and a VHF radio beacon (Channel 77) that transmits a CW pulse about every 4 seconds.   The flash can be seen through the white translucent hard hat of the IES and the radio can transmit (@ 100mWatts) through the glass & hard hat… radio range varies with sea state from ½ to 2 miles.   Radio direction finder (RDF) receivers are available to indicate relative bearing, e.g., those made by Taiyo (see web site www.taiyomusen.co.jp) and NovaTech Designs Ltd. (see web site www.novatechdesigns.com).   Also see Chapter 8.3.3.   The RELOC module is activated when the IES RELEASE relay is activated, but uses an additional tilt switch to keep the radio/flasher OFF until the IES turns over (acoustic transducer facing DOWN)… this will be the orientation of the IES when it is on the sea surface. Once on the surface, the RELOC module will continue to be active until the IES batteries (both system and release batteries) are exhausted. A photoelectric switch controls the flasher, which only operates in darkness. After the release is activated and the IES is on the surface, the RELOC module will operate for about 60 hours with a 30 Amp-hr stack of release battery cells or 120 hours with a 60 Amp-hr stack of cells.

Remember! – The RELOC radio/flasher module only operates when the acoustic transducer is facing DOWN and the flasher only when it is dark.

6.4   FAIL-SAFE CIRCUITS

- **Watchdog Timer**

  A "watchdog" alarm will attempt to restart the instrument if the IES computer module is inactive longer than 12 minutes. The IES wakes up from sleep mode every 10 minutes to check its measurement schedule and resets the watchdog timer… missing one of these 10 minute timer resets will cause the watchdog to RESET the IES after about 12 minutes. The watchdog timer circuit operates with an independent time base and is powered exclusively by the system battery. The watchdog is operating whenever the IES is in data acquisition mode but is disabled when the IES is in menu mode or when an acoustic or timed release is detected. The time of each IES RESET will be noted in the "IES###.log" file as outlined in Section 4.3.1. The watchdog timer is independent of the acoustic command subsystem and does not monitor or control its operations. However, if the watchdog resets the IES, the IES will, in turn, reset the acoustic command controller and release relay, i.e., the entire instrument gets reset. If the IES system battery is exhausted, the watchdog timer is no longer operative.

- **Battery Independence & Low Voltage Monitor**

  The model 6.2 IES has two independent batteries… system and release.   The IES is designed such that if the system battery is entirely exhausted, the release battery will support all recovery features. When the system battery falls below 6.0 volts, the data acquisition system will save all data, cease collecting further data and enter a low-power sleep mode. Alternatively, if the release battery fails, the system battery will operate the recovery functions, although, due to the lower voltage, the burn time of the release mechanism will be as much as three times longer and the acoustic responses will be 12dB weaker. If the system battery is exhausted, the auto-release function will no longer be operative.

6.5   DYNAMIC CLOCK ADJUSTMENT

The time base (crystal oscillator) of the IES real time clock (RTC) is integral to the IES's CF1 computer module. The CF1 is the computer engine that controls the IES data-collecting schedule.   The CF1 time base has an unacceptable frequency tolerance (30 – 60ppm) over the IES operating temperature range (0-25°C). This can result in an IES clock drift of up to 5 seconds/day or 30 minutes/year!). To correct this problem the IES periodically measures the RTC oscillator frequency using the IES's super-stable Bliley crystal oscillator and corrects the IES clock. This correction should keep the IES clock accurate to within an estimated 10 seconds/year.

The IES dynamic clock adjustment works as follows: At the end of each measurement hour (after the xx:50:00 scheduled activities), the IES will use its YSI thermistor circuit to measure the ambient temperature inside the IES . This value is used to apply temperature compensation to determine the reference frequency (Bliley oscillator). The IES will then (using the Bliley oscillator as a reference) measure the CF1 RTC frequency and calculate the clock drift during the previous hour based on the error from the nominal value of 32768Hz. *Note that this assumes the temperature has been stable during the previous hour*. The IES will sum the errors from each hour's calculation until the clock drift becomes greater than 1.0 second. The IES will then adjust the RTC appropriately by 1.0 second and reduce the error sum by 1.0 second. Ideally, if the operating temperature is stable, the IES clock will never be in error by more than 1.0 second, however, temperature fluctuations on the order of 1°C in 30 minutes will introduce additional small errors.

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Chapter 7   IES ASSEMBLY INSTRUCTIONS

Note: While reading this chapter, refer to the IES Parts Location drawing Figure 1-1 in Chapter 1 to see the proper positioning of the elements in a properly assembled IES.

General precautions for sealing glass instrument housings are provided in a separate document provided by Nautilus Marine Service, Bremen, Germany (See Appendix A.1). Specific instructions for sealing the IES model 6.2 are provided in this chapter. The assembly procedure is divided into two parts; 1) sealing the electronics in the glass sphere, and 2) installing the sphere in the hard hat.

First some notes about the use of glass instrument housings.

7.1 GLASS INSTRUMENT HOUSINGS

Although new users of this type of instrument housing are initially apprehensive about handling glass, they usually become advocates because most of the corrosion issues concerning undersea equipment disappear. The most important advice we can offer, after hundreds of successful deployments, is the need for cleanliness during the seal up process. ***Clean your hands with rubbing alcohol before*** cleaning the glass mating surfaces and the o-rings. **This is very important!** Once your fingers are clean of grease they become excellent detectors of any dirt or grease on the glass… gently slide your clean finger over the glass mating surfaces. The glass itself should be cleaned with a residue-free solvent such as toluene. ***Make sure that you have adequate ventilation when using strong solvents… the fumes are hazardous to your health.***

The preferred method of sealing the sphere is to remove most of the air from inside the sphere with a vacuum pump. This removes most of the moisture that can condense when the sphere is cooled at ocean depths and also provides an indication of how well the sphere is sealed prior to applying the sealing tape. Simply remove the vacuum port screw and hold a plastic hose to the port until the vacuum sensor needle points to the green dot (this is about ~14" (36cm) Hg). The vacuum port is so small that pulling the plastic hose away and ***quickly*** inserting the sealing screw will not allow enough air back into the sphere to change the vacuum significantly. Replace the vacuum port o-ring after every deployment. Examine the o-ring on the sealing screw with a magnifying glass and remove any dust particles. The o-ring should be lightly greased with o-ring lubricant.

Since the IES is usually deployed in a low temperature environment, it is important to perform the glass housing closure in a dry atmosphere AND include packets of desiccant (silica-gel) to prevent any condensation collecting on the IES circuit board.

An alternative to using the vacuum pump to seal the hemispheres is to direct some warm air from an electric hair dryer inside the sphere as you close it up… as the air cools, a vacuum will develop that will hold the hemispheres together. ***Be careful not to overheat the electronics!*** If the hemispheres do not seal, check for grease or dirt particles on the glass sealing faces. If you use this method, it is ***particularly*** important to install desiccant (silica-gel) to absorb condensation.

7.2 SEALING THE GLASS SPHERE

After the battery assembly has been attached to the IES electronics, follow these steps to prepare the electronic assembly for sealing in the glass sphere:

1. Select the glass hemisphere with the acoustic transducer attached and support it so that the transducer is pointing down and the open hemisphere is facing up… like a bowl. One of the foam blocks from the shipping container is ideal for this operation.
2. Pull the IES transducer cable from inside the glass and hang it over the side of the hemisphere.
3. Install packets of fresh, dry desiccant in the orange desiccant sock on the IES frame.
4. ***Make sure that both hemispheres have matching serial numbers and that the pressure transducer is the correct one for the IES.***
5. Lift the IES electronics assembly with the finger holes (battery on the bottom) and lower it between the rubber bumpers on the side of the glass. Keep all the yellow arrow labels (on IES and glass) on the same side of the hemisphere.
6. Rotate the IES electronics assembly until it is firmly wedged under the rubber blocks. Align the yellow arrow labels of the electronics package with the yellow arrows on the glass. ***Make sure that the transducer cable is not pinched between frame and glass***.
7. Plug the transducer cable into connector J1 (see Figure 2-1).
8. Set the output driver switch S1 to XMT (see Figure 2-1).
9. Set the ON/OFF power override switch S2 to REMOTE (see Figure 2-1).
10. Clean the glass sealing surfaces on both hemispheres as described in Chapter 7.1.
11. While one person holds the other hemisphere, rim downward above the first hemisphere, a second person plugs the pressure sensor cable into J6 of the IES board, the external cable into J3 of the IES board.
12. Close the hemispheres and align their outside edges. Rotate the top hemisphere to align the yellow arrows and serial numbers of the glass.
13. Open and examine (with a magnifier) the vacuum port. Clean the port and sealing screw. Replace the o-ring if necessary using a little o-ring lubricant (see Section 7.1).
14. Using a vacuum pump and clean rubber hose, evacuate the air from the sphere to 20"(50cm)Hg vacuum and quickly replace the port sealing screw (see Section 7.2). Confirm a good seal by trying to slide the hemispheres apart… they should not move. See **Warning below.
15. Wrap the soft sealing (goop) tape around the equator joint of the sphere, overlapping the ends ~ 0.25" (0.6cm). Before removing the backing paper from the tape, flatten the soft tape with a roller to half of its original thickness.
16. Wrap two layers of the 2"(5cm) wide plastic tape over the soft tape. Smooth out any trapped air bubbles.
17. Install the plastic belt and rubber handles at right angles to the equator joint as shown in figure 7-1 (note the position of the lifting handle, buckle and clasp relative to the top of the assembly). Adjust the buckle of the belt so that when the belt ends are joined together the belt is tight around the sphere. Put a tape strip across the lifting strap on both sides of the lifting handle as shown in Figure 7-1 and 7-2. The IES sphere assembly is now ready to be installed into the hard hat.
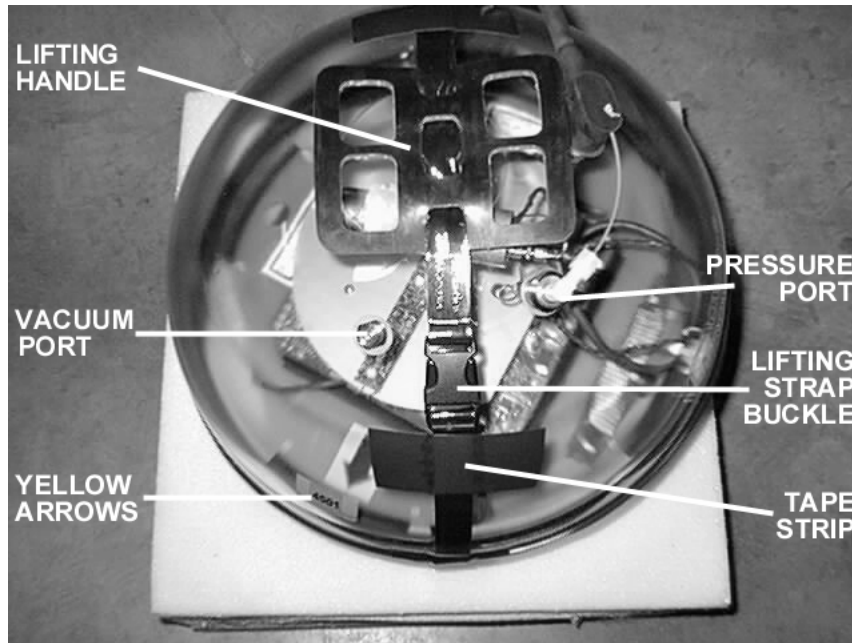
Figure 7-1   IES Sphere Assembly

> ***Warning: Even a slight vacuum will firmly hold the glass hemispheres together. If the IES is going to be shipped by air, it is important that a vacuum of 1/3 atmosphere be created inside the sphere to prevent the pressure differential at high altitudes from forcing the sphere open. However, **do not create a vacuum greater than 20"Hg vacuum** because arcing between high voltage components may occur.*

7.3 HARD HAT ASSEMBLY

After the electronics are sealed inside the glass sphere, follow these steps to install the sphere inside the white plastic hard hat as shown in Figure 7-2. The hardware required to assemble the hard hat is shown in Figure 7-3.

*Warning: During this assembly procedure, the "upper" hard hat is actually **under** the "lower" hard hat. In the following steps, don't get the terminology mixed up... "upper" and "lower" refer to names of the hard hats, as shown in Figure 7-1, and not to their position in this assembly process.*

1. Start with the "upper" hat section on the floor... resting on the acoustic transducer guard.
2. Lift the IES sphere assembly by the rubber lifting handle (transducer pointing down) and lower it into the hard hat... rotate the IES until the yellow arrow label on the edge of the hard hat is aligned with the yellow arrow on the glass hemisphere. See Figure 7-2.
3. Place the "lower" hard hat over the sphere, rotating it to align the green arrow labels on the inside edges of the hard hats.
4. As you are placing the "lower" hard hat, pull all the connectors on the IES external cable through the hole in the hat beside the release block. Be careful not to disturb the plastic fitting on the sphere pressure port.
5. Install the nylon bolts and nuts that clamp the two plastic hard hats together; install the nylon flag holder hardware. Use nylon washers on both sides when bolting the two hard hats together.
6. Install the release block as shown in Figure 7-3. Orient the release block so that the anode/cathode connectors are nearest the hole in the hard hat assembly.
7. Apply a small amount of o-ring grease to the mating surfaces of cable and connectors. Plug in the release block cables and the yellow RS-232 communications cable sealing plug. When you are ready to turn the IES ON, grease the red ON/FF plug and install it. When the red plug is installed, the IES will turn ON and acoustically respond as outlined in Chapter 2.2.2.
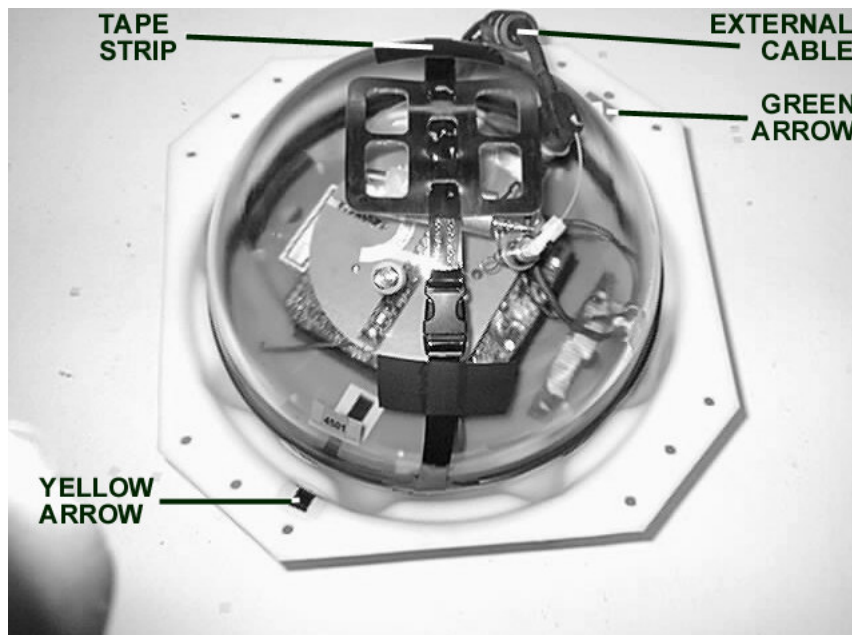
Figure 7-2 Placing the Sphere in the Hard Hat

4

(8) 3/8-16 x 1.5" bolts

(8) 3/8 washers

(1) 1/2"-13 x 1.5" bolt
(flag base nut)

(1) 1/2" washer

UPPER hard hat

(2) 3/8-16 nuts

(2) 3/8 washers

LOWER hard hat

(8) 3/8 washers

(1) 1/2" washer

(1) 1/2-13 nut

(8) 3/8-16 nuts

Flag holder

(2) 3/8 washers

(2) 3/8-16 x 1" bolts

Release Block Assembly

(4) 3/8-16 x 2" bolts
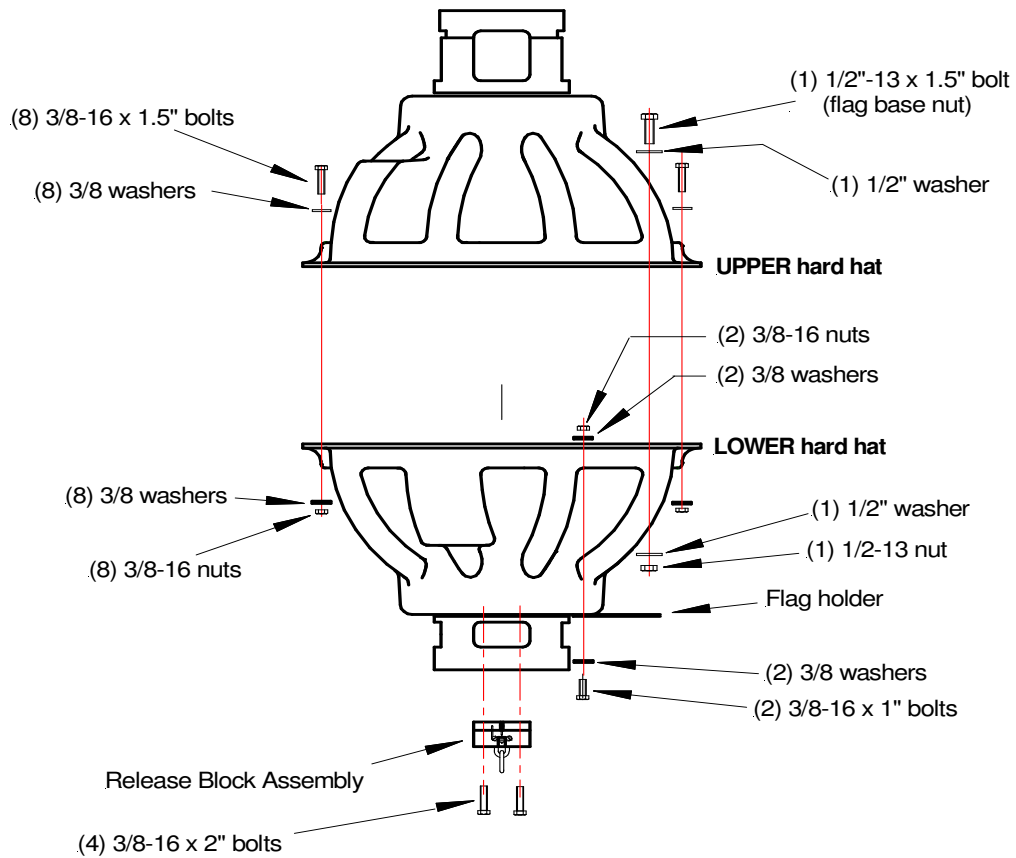
Figure 7-3   IES Hard Hat Assembly Hardware

7.3 BURN-WIRE RELEASE MECHANISM

The burn-wire release mechanism used on the IES Model 6.2 has been used in hundreds of successful IES recoveries. However, the following details must be adhered to, without exception, otherwise omitting a small detail could result in the IES never releasing from the sea floor.
- use only URI-GSO replacement parts (see Appendix D.1 for part numbers)
- follow PRECISELY the release block assembly instructions in Appendix D.2

7.4 PRESSURE & VACUUM PORTS

Both the pressure port and the vacuum port are made from titanium alloy to minimize corrosion. The internal plumbing that connects the pressure port to the pressure sensor has been tested to 10,000 psia ($6.9x10^4$ kPa) for 48 hours to assure safe deployments to full ocean depths. If the pressure sensor is changed, the internal fitting seals should be retested to comply with the anticipated deployment depths. Between deployments be sure to perform the pressure port maintenance procedures outlined in Chapter 9.1.1. The only o-ring in the pressure port assembly is between the titanium port and the glass and can be inspected from inside the hemisphere.

The vacuum port has two o-rings: one between the port and the glass sphere and another between the port and the external sealing screw. The o-ring seal between the port and the glass can be inspected from the inside of the glass sphere… make sure that the rubber is flat against the glass. Since the port sealing screw is removed and reinserted for every deployment, great care should be exercised in examining the o-ring and sealing surfaces for dirt & wear... ***use magnifying glasses to examine these pieces… a leak here is catastrophic!***

Chapter 8   AT SEA OPERATIONS - IMPORTANT DETAILS

8.1 DEPLOYMENT

For its measurement capabilities, the IES Model 6.2 is small and inexpensive. However, its release mechanism is somewhat delicate and requires a little care during the launch procedure. ***It is important to follow the launch guidelines in this section!***

IMPORTANT: To assist in keeping a record of important numbers and times, an **IES Deployment Form** *is provided in Appendix E of this manual. Make a copy of this form for each IES prior to deployment and fill in the blanks during launch operations. This form has been used at URI-GSO and found to be valuable at IES recovery time when trying to reconstruct what happened at deployment time, e.g., "where did we put the IES and what is its release code"?*

8.1.1   Launch Precautions

- The IES can be launched using an A-frame, crane, or any lifting mechanism that allows you to lift the entire instrument, including the anchor (see the following section), off of the deck ***and then*** swing the entire assembly over the side and into the water. A 5/16" (8mm) diam. fiberglass pin supports the IES anchor. This pin has a breaking strength of 300-400 kg. The integrity of this assembly should be checked by first raising the IES and anchor off the deck and checking for any slippage of the release block parts, **before** moving the system over the water. In this way, if there is any failure of the delicate release block parts, the anchor will fall to the deck and not in the water. Have a fully armed release block assembly ready to install in case of problems.
- As stated above, the weakest release block part has a breaking strength of 300-400 kg. Even though the anchor will weigh about 50kg, this limit can easily be exceeded if there is any jerking of the lifting line during launch. If the lifting line is a steel cable this problem is significantly exacerbated; a one meter loop of nylon line should be inserted between the steel cable and the quick release hook to act as a shock absorber.
- If the IES acoustic release has been accidentally activated during previous operations it will not be obvious since the 4-sec. pinger does not become active unless current is flowing through the release block via the sea water path*. **Immediately before launch, momentarily connect the anode to the cathode of the release block**… if the 4-sec. pinger comes on, the release relay has been accidentally activated and the IES must be RESET. To RESET the IES simply turn it OFF, then ON, and wait for the double ping that indicates proper resumption of the mission (refer to Chapter 2.2.2). This action will not alter the internal clock, mission configuration, or the data files, so the deployment can continue. A record of this extra RESET will appear in the IES###.log file.
- It is also important to check the IES vacuum seal just before launch. You can see the vacuum gauge (altimeter) thru the communications cable access hole. Confirm that the gauge needle points to the green dot… if the needle has moved counterclockwise toward the red dot, the launch should be aborted and the IES re-sealed.

8.1.2 Selecting and Attaching the IES Anchor

Almost any kind of high density mass can be used as an IES anchor. A variety of salvaged objects have been successfully used; auto engine blocks, sections of train rails, old ship's anchor chain and lead-embedded concrete blocks. Since the IES is usually deployed for long periods of time, corrosion between dissimilar metals in the anchor assembly and attachment mechanism should be taken into consideration… the integrity of the IES attachment point and the overall mass of the anchor should not be compromised due to long-term corrosion properties.

The pressure sensing circuit in the IES is so sensitive that it will detect small changes (<1mm) in the height of the IES from the sea floor… deterioration of the mooring system or its response to variable bottom currents will contaminate the pressure measurement. This is the reason that long (>1.0 meter) anchor lines should NOT be used. If an IES with a pressure sensor is to be deployed at a site with an anticipated maximum bottom current flow greater than 0.6 knot (30cm/sec), a rigid mooring stand should be utilized… consult URI-GSO for more information regarding this application.

When choosing and attaching the IES anchor, follow these general rules:
- Select an anchor that weighs between 100-120lbs (45-55 kg) in air and at least 88lbs (40kg) in water.
- Use a 5/16" (8mm) diam. nylon or dacron anchor line that will position the IES 1.0 meter above the seafloor.
- Attach the anchor line at the center of mass of the anchor so that the IES cannot pick up one end of the weight. For example, if using salvaged anchor chain, clump the chain together so that it reacts as a single mass… see Figure 8-1.
- Double wrap and tie the line <u>tight</u> around the anchor to minimize abrasion.
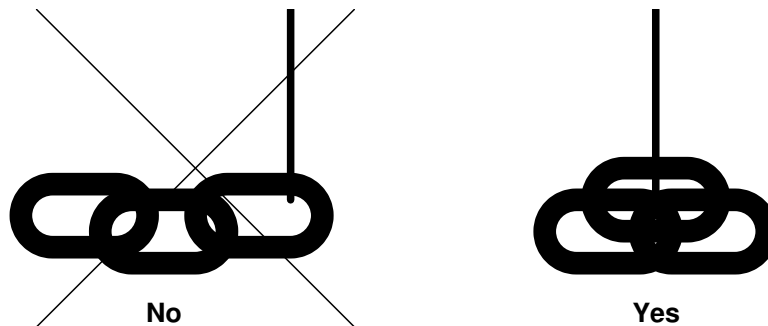- Add security to all knots in the anchor line with plastic cable ties.

Figure 8-1 Using Salvaged Chain as an Anchor - Attaching the Anchor Line

8.1.3 Acoustic Tracking Operations

This section describes the ***use*** of the Acoustic Command Subsystem (ACS) during deployment operations. Descriptions of the ACS subsystem and the commands themselves are provided in Chapter 5. It is assumed here that the user understands the setup and the functions of ACS commands as described in Chapter 5 and that some type of acoustic tracking system (receiver & line scan recorder) is available on the ship.

Using the ACS, there are two methods of determining the location of an IES on the sea floor:

- Sending the XPND (transpond) command will initiate the IES transpond mode. In this mode the IES will immediately reply with a 12.0kHz ping whenever it detects a 12.5kHz interrogation ping from the ship. Using an EdgTech model 8011A or Benthos model DS-7000 deck box in the ranging mode, the slant range from ship to IES can be determined… but not bearing. If the ship is equipped with a hull-mounted transducer that can transmit the 12.5kHz interrogation pings, the operator can maneuver the ship while continually updating the slant range… bearing can then easily be determined. Alternatively, if a lowered hydrophone is used, a minimum of three slant ranges should be measured, each from a different (GPS-measured) ship position. Knowing the depth of the IES, these measurements give the IES position.

- Sending the BEACON command will initiate 20 minutes of BEACON mode… a 12.0kHz ping at an 8 second rate. This mode cannot be used to determine range, but can be used to determine relative bearing by maneuvering the ship and monitoring the line scan recorder. When the ship is on a straight-line course, the line to the IES (fixed on the bottom) is perpendicular to the course line at the point of closest approach, as indicated by a minimum-time in the line-scan trace. The BEACON mode is normally used during IES recovery operations when the ship can only listen, i.e., does not have the capability of transmitting transpond pulses while maneuvering.

Immediately after launching the IES, put the deck box transducer in the water (if the ship lacks a suitable hull-mounted transducer) and send the XPND command. Set up the deck box in continuous ranging mode with 12.5kHz as the output frequency and 12.0kHz as the receive frequency. The interrogation pulse should be >20 milliseconds long. The slant range will be displayed on the deck box during the IES descent. When the IES reaches the bottom, the slant range indicated should stablize and be close to the water depth*. **DON'T FORGET: the transponder will be quiet during travel time measurements!.. note the measurement schedule when using acoustic commands… and remember to disable the transpond and telemetry functions with the CLEAR command before departing the site. If you do forget to disable these functions the model 6.2 IES will disable them at midnight (by the IES clock).***

Note: Software is available to convert an inexpensive laptop computer into a line scan recorder that works well for these acoustic tracking operations. It is available from Chaplin Marine Instruments, Sherborn, MA, 01770, USA. Inquire about TRAX-4 software at their web site: **www.cmari.com**

8.1.4 Acoustic Telemetry Operations

The Model 6.1 is equipped with an acoustic telemetry scheme to verify the correct operation of its measurement systems ***immediately after*** it is deployed. A similar scheme is used to collect data from the IES in lieu of recovering the instrument, i.e., ***during*** a deployment.

To use the IES acoustic telemetry option, the following additional equipment and software are required:
  - ➢ Benthos Inc, Model DS-7000 Acoustic Transceiver Deck Box configured for 4 channels (IES & PIES applications) or 8 channels (C-PIES application).
  - ➢ The Model DS-7000 must also have special firmware installed to transmit IES codes. Contact Benthos, Inc. Falmouth, MA, USA for pricing.
  - ➢ The shipboard telemetry receiver uses software from The MathWorks (Matlab 7 for Windows) to interface with the DS-7000 deck box and display the incoming data. Matlab programs to implement IES acoustic telemetry are available from URI-GSO.

Telemetry operations are rather complex and cannot be summed up in a few paragraphs… refer to Chapter 10 "Advanced Acoustic Telemetry Option" for a description of the technique and instructions on how to use it.

After the IES is on the bottom, perform the following test to determine that the travel time measurements are correct.
  - • Send the TELEM command to the IES.
  - • Verify that the IES responds with its 'two ping' command acknowledgment… if it does not, send TELEM again, and again, until the correct reply is received.
  - • If you know the depth at the IES site, you can calculate what the telemetry time should be. For example, if the water depth is 3000 meters, the round trip travel time that the IES measures will be 4 seconds (assuming sound speed at 1500m/sec).
  - • Note the lockout time for each IES deployed. If the telemetry number is in error and is a time close to the lockout time, it means that the IES echo detector is too sensitive to ocean noise or the IES output power is too high. In either case, adjustments should be made before leaving the IES at the site. Of course, telemetry values much larger than expected, given the water depth, indicate that the echo detector is not sensitive enough or the IES output power is too low. In either case, if additional telemetry tests confirm a problem, the IES should be recovered and adjustments made… see Chapter 2.3.3 and 3.6 for related topics.

Sending the CLEAR command and verifying the 2-ping acknowledgment will acoustically disable TELEM mode*.* If you forget to disable the TELEM mode before leaving the deployment site, the IES will disable the function at midnight, IES time.

8.2 RECOVERY

The IES is a small package that gets left in a big ocean. Besides the obvious tools used to relocate and recover an IES, e.g., reliable shipboard navigation and acoustic systems, as well as diligent record keeping, a number of relocation and recovery aids are built into the instrument. This section of the manual outlines the *use* of these devices during recovery operations… refer to other sections of the manual for descriptions of the devices. A summary of IES relocation and recovery aids:
- Acoustic Command Subsystem (ACS)
- Burn-wire release mechanism
- VHF radio beacon and xenon flasher module (RELOC Module)
- flag and reflective tape
- floating recovery line

8.2.1 Acoustic Commands

After arriving at the deployment site:
- Listen for the IES travel time measurement pings and determine the IES clock offset… remember that the ACS responses will be blocked during travel time measurements… so note how the clock error will affect the IES measurement schedule and the ACS operations. Remember also that there is a short time delay resulting from the sound propagation time through the water.
- Send the XPND command and determine the slant range to the IES… if it is much greater than the water depth, maneuver the ship until it is suitably near the IES.
- Send the RELEASE command and verify the acceptance of the command by hearing the six pings at 2-second intervals.   The burn wire mechanism will take about 15-20 minutes to drop the anchor.   If there is *only a two ping* response, check your records to be sure that you are sending the correct code! Two ping responses mean that the IES ACS is working fine but is not recognizing the command as a release command… double check your records and the code entered into the deck box.
- Once the release command has been accepted and the burn wire release is activated, the IES will start to ping at a 4 second rate with its maximum power output. Monitoring the ship's line scan recorder, you can see when the IES leaves the bottom. The model 6.1 IES will rise at about 60-65 meters/minute (depends on the weight of batteries), so knowing the water depth, the time of arrival at the surface should be roughly predictable.

8.2.2 Burn-wire Release Mechanism

In the deep ocean, where the sea water temperature is about 0-5° C, the burn-wire release takes about 15-20 minutes to drop the IES anchor… slightly faster where the water is warmer or more salty. The IES must sense the current flowing in the burn-wire before it begins its 4-second rate, 12kHz beacon.

8.2.3 RELOC Module

When the IES releases from the sea floor, it will invert and a tilt switch will turn ON the RELOC module. The standard RELOC module consists of a radio beacon (156.875MHz (marine band, channel 77) – 1 second long pulses, 3 seconds apart) and a xenon flasher (1 million candlepower - about 1 second flash rate) with a light sensitive switch.

An inexpensive, hand-held, radio direction finder can be obtained at:
> L-Tronics, Inc.
> Santa Barbara, CA, USA 93111
> (tel: 805-967-4859)/, web address: www.ltronics.com/portable.htm
> Model: Little L-Per VHF receiver tuned to channel 77   ~$500

A sophisticated, IES-compatible direction finder with a ship's mast antenna can be found at:
> Taiyo Inc, Japan   web address: www.taiyomunsen.co.jp
> Model# TDL-L1620A RDF.

8.2.4 Flag and Reflective Tape

The IES is equipped with an orange flag with reflective edges (23cm x 46cm) that stands about a meter above the sea surface. With the IES's reflective tape and xenon flasher, it is, in some ways, easier to recover the IES in the dark than in daylight.

8.2.5 Floating Recovery Line

The IES has a 10 meter polypropylene line and float attached to the hard hat bridle. This line will float on the surface and a grappling hook can be thrown across it from the recovery ship to bring the IES alongside. The recovery line should not be used to lift the IES aboard but should be pulled taught from the ship so that the bridle loop is exposed. A hook attached to a lifting mechanism should then be attached to the bridle and the IES lifted aboard by the bridle. During lifting (and launching), use the recovery line as a control line to prevent the IES from swinging and twisting.

Chapter 9   MAINTENANCE

9.1 PRESSURE SENSOR

If the IES is equipped with the pressure measurement option, the plastic pressure fitting (oil reservoir) projecting from the titanium pressure opening in the glass sphere must be cleaned and the oil supply in the sensor plumbing must be replenished after every deployment. Following the simple procedures detailed below can prevent marine organisms and/or silt from blocking the sensor port and sea water reaching the internal metal parts.

> *WARNING: Do not remove the threaded titanium fitting (pressure port) from the glass sphere or allow it to rotate! The sphere and the sensor plumbing must be pressure tested if the titanium fitting is disturbed.*

9.1.1 Cleaning & Filling the Pressure Port

Use a 7/16" (12mm) wrench to remove the plastic oil reservoir fitting from the pressure port; do not remove the threaded titanium fitting or allow it to rotate (hold it with a 7/8" [23mm] wrench). Thoroughly empty and clean the fitting and port entrance with a cotton swab to remove any sea water, silt or marine growth. Next, refill the port entrance with oil by using a hypodermic syringe to inject Dow-Corning fluid 350-CS into the pressure port until the fluid is in a puddle on the top of the port, level with the sphere's surface. After adding the fluid, poke the syringe into the port to break any bubbles that may have formed during the filling process; add more oil if necessary. Fill the oil reservoir in the plastic pressure fitting in the same manner. Quickly flip and install the reservoir fitting into the port. Oil, without air, should ooze from the end of the fitting tube as you tighten the fitting. Be sure that the excess oil does not seep into the o-ring area under the titanium fitting. The reservoir fitting should be tightened by hand leaving the reservoir tube facing *away from* the vacuum port.   A pictorial of these operations is shown in Figure 9-1.

Medical syringe

oil reservoir

(Oil)
Dow Corning
350 - CS

Glass sphere

Pressure port

Pressure sensor

Fill pressure port and reservoir with oil until a puddle forms. Eliminate air bubbles with a clean wire.

Install reservoir, allowing excess oil to flow out. Repeat the process if air bubbles are visable in reservoir tube. Rotate reservoir fitting until tube points <u>away</u> from vacuum port.
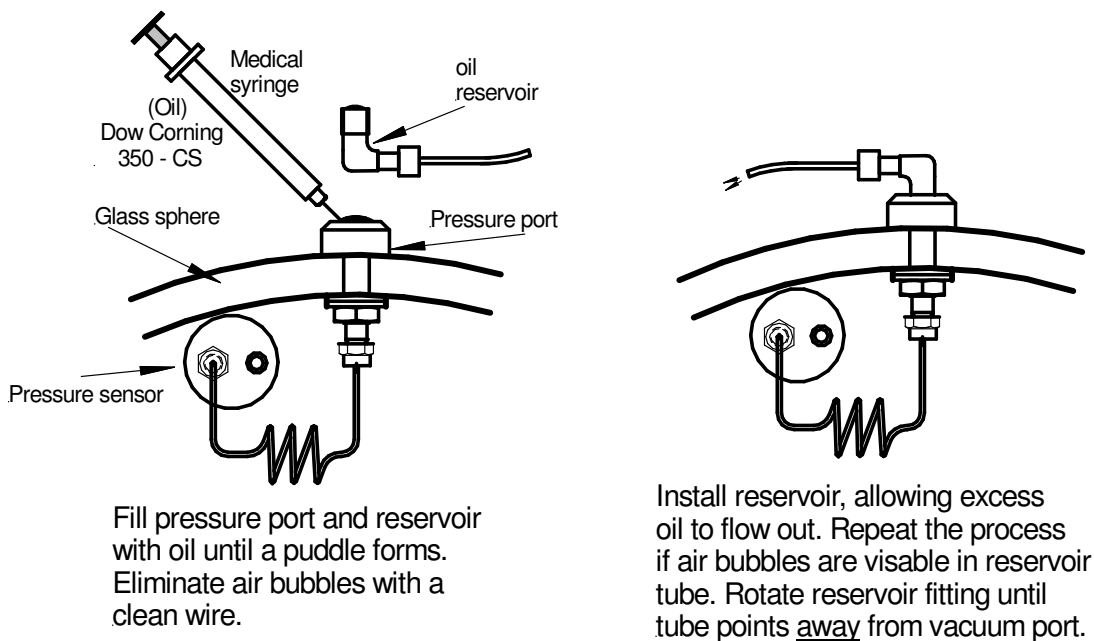
Figure 9-1   Filling the Pressure Port

9.1.2 Pressure Sensor Calibration

A calibrated dead-weight tester should be used to verify the accuracy of the pressure sensor between deployments. For this test, the plastic fitting on the pressure port must be removed and an appropriate high-pressure fitting (Parker # 1M3SC2 male connect to 'o'ring pipe thread) installed between the pressure port and a dead-weight tester. ***Before performing a calibration test, be sure that the IES is properly configured as follows:***

- sealed in its glass sphere
- at a stable temperature for more than 6 hours
- is correctly oriented with the acoustic transducer facing UP
- the correct pressure and temperature offsets are installed (see Chapter 3.5)
- no air in the pressure plumbing system
- the dead-weight tester must be at the same height as the pressure sensor, or a hydrostatic offset must be introduced

Attach the external communications cable to the IES and go to the IES Self Test Menu. Use selection "D" to acquire pressure measurements. The IES reported pressure should indicate within 0.015% of full scale the known pressure applied to the sensor by the dead weight tester. Apply pressures over the full scale range, being careful not to exceed the full scale value. If the pressure data reported in the record are in error, contact Paroscientific Inc. for information on re-calibrating the pressure sensor at the factory. Contact information is available from their web site: **www.paroscientific.com**
URI-GSO does not maintain a re-calibration facility.

9.2 INSTRUMENT HOUSING

Although there is little that can render the hardhats unusable, it is a good idea to look over each of the parts prior to a deployment. The hardhats are extremely flexible and should not crack.

It will be obvious when a glass sphere is no longer fit for deployment. However, a small amount of chipping, or spalling, may occur around the inner edges of the hemispheres in response to high pressure during testing or operation. This is a normal stress relieving mechanism of the glass and has only minimal effect on its strength. In general, if the glass will hold a vacuum, it will be safe from ***low-pressure leaks***; if any chips along the seal do not extend more than 1/5 of the thickness of the seal, the sphere should be safe to use to 4000 meters depth. Of course, ***if there are any doubts, the safest procedure is to pressure test the sphere without the electronics.***

9.3 GLASS PENETRATORS

Examine each cable connected to the glass penetrators for cracks, cuts and deterioration of the neoprene rubber. Replace any suspicious-looking parts; the consequence of a failure of the penetrators or attached wires is so severe, it is not worth taking any chances. It is normally not necessary to pressure test the sphere after changing a penetrator. The integrity of the penetrator o-ring seal is easily visible from inside the sphere.

For even greater peace-of-mind, run a high voltage megohm test on the glass penetrators in a bucket of salt water. Insert dummy plugs into the penetrator cables. Immerse the outside of each hemisphere (with penetrators & cables) in a tub of salt water and measure the resistance between an electrode in the water and the penetrator terminal inside the glass. Since the penetrators on the pinger hemisphere carry such large voltages (2500 volts), a high voltage megohmeter should be used.

At URI-GSO, we test the IES penetrators after every two deployments using a 5000Volts megohmeter and reject any that show a resistance of <100MegOhms.

9.4 RELEASE BLOCK

A detailed drawing of the "burn wire" release mechanism is shown in Appendix D.1. A diagram of the release block assembly procedure is in Appendix D.2. *It is very important that every detail of this assembly procedure is followed precisely.*
Some additional important notes on the release mechanism:

- Even though the cathode wire does not get destroyed during the release activity, it is a good idea to replace it every 2-3 deployments. Some users report that the contacts in the cathode (female) connector relax after repeated use and reliable connection is lost.
- Be sure that there is 1/8" (3mm) of play between the end of the fiberglass pin and the cathode wire… no more, no less.   Under high pressure the release block compresses more than the pin, so the pin could be jammed at release time if this clearance is not maintained.
- Before assembling the release block, when you have all the parts together, it is a good idea to simulate the release activity; moving all the parts through their release anticipated paths. This will confirm that there is no error in parts size.
- USE ONLY URI-GSO PARTS - ANY SUBSTITUTION MAY RESULT IN THE LOSS OF THE INSTRUMENT !!

9.5 Loading New Firmware

IES firmware upgrades may become desirable to improve performance, add features or to add some custom functions for a specific project. IES firmware upgrades will be sent to you in the form of a IESe***.APP file on a floppy disk. The *** will indicate a year, month and day, such as IESe1_ 9_11.APP for September 11th 2001. This file will be transferred to the IES using a communications program from your **IES User's Software Disk** (Motocross.exe) as follows:

1. **Run MotoCross.exe** (it's on your IES User's Disk) and connect to the IES at 57600 baud (see MotoCross **File** menu - **Communications Settings** to change baud rate of PC). See Chapter 2 for IES communications details.
2. RESET or power cycle the IES, press the **<space>** bar and proceed to the Main Menu.
3. Select '**P**' (this is a hidden menu selection) to get to the PicoDOS mode prompt: **c:\>**
4. From the **MotoCross Toolbar 'Transfer' Menu**, select '**Load CPM68K**'
5. In the MotoCross window, find & select the new firmware file that was sent to you named: '**IESe***.APP**'
6. After the new firmware is in place, the transfer window will close and a "**G**" appears at the **c:\>** prompt), press <enter> and the new IES application will start.
7. Be sure to verify that the new firmware is in place by examining the IES banner header that is displayed immediately after RESET. The IES version date should match that in the documentation shipped with the new firmware (same year, month and day as in the filename IESe***.APP).

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Chapter 10 - Advanced Acoustic Telemetry Option
(for PIES and C-PIES Hardware Configurations)

If a Benthos DS-7000 Acoustic Deck Unit with a 4-channel receiver is available (8-channel for C-PIES applications), the IES Model 6.2 advanced telemetry option may be utilized. In addition to the deck unit, the appropriate URI-GSO telemetry receiver & display programs, running on Matlab 6 release 13 (or above) are required to implement IES advanced telemetry.

When the IES is deployed and configured for advanced telemetry there are two data reporting protocols that can be remotely activated (acoustically, via the DS-7000 deck box): **burst** telemetry and **file** telemetry.   When the IES receives the 'TELEM' command, only one of the protocols will be activated, depending on the time relative to the start of the mission, as follows. After the IES mission is started, **burst** telemetry will be available until the IES has collected enough data (three full calendar days) to implement the data processing (de-tiding) routines. After enough data have been collected to make data processing meaningful, the IES makes **file** telemetry available exclusively. Both protocols use the same acoustic technique and general format (called pulse delay telemetry - PDT) to transfer the data from the IES to the surface. Both techniques are outlined as time lines in Figures 10-1, 2 & 3. Refer to these figures during the following discussion.

10.1 PDT Telemetry Technique

The idea of sending information by encoding data as the delay in arrival time between two acoustic pulses has been used for years. The method has had a number of names… it is referred to here as pulse delay telemetry (PDT). The primary feature of PDT that makes it attractive relative to other encoding techniques, e.g. bit, rate, FSK or spread spectrum encoding, is its very low power requirement and high reliability. The primary drawback, relative to the other techniques mentioned, is its low speed or data throughput.

With its adjustable resolution, PDT is inherently reliable (just slow it down until it works!) and, when using multiple frequencies, the technique is relatively immune to multipath acoustic interference.

In the IES application, the low data-rate issue is solved by preprocessing the data in situ to produce mean values for a 24-hour calendar day. Hence, depending on whether the application is a PIES or C-PIES configuration, a block of data representing a full day's measurements (year-day, tau, pressure, current speed and heading), can be transferred from the sea floor to a surface ship, in 24 or 30 seconds respectively.

Note: The following text describes the telemetry protocol for C-PIES configuration (data includes tau, pressure, current speed & heading. The protocol for PIES configuration (data includes tau & pressure only) is essentially the same with the data records being shorter. The C-PIES records are outlined in the figures, and the PIES records are simply truncated, i.e., the speed data are eliminated and the record frame shortened appropriately.

10.2 IES Data Processing for File Telemetry

The data processing techniques used by the Model 6.2 during its deployment period (in situ) and transmitted by file telemetry are nearly identical to those historically used in the laboratory at URI-GSO <u>after</u> the IES is recovered. GSO has compared the products of both processing routines and found there to be no substantial difference from routinely good data. A brief description of the steps used to process tau, pressure and current meter data in situ follows:

10.2.1 tau data: The 24 measurements of travel time, collected every hour, are de-spiked and sorted at the end of each hour. The values are then windowed within +/- 3 standard deviations of the median (keeping the central 99.73%) and the 1st quartile value of that list is saved until the end of the 24 hour calendar day. At the end of the day, the 24 hourly values are again despiked, sorted, 99.73% windowed, resorted and that median value is saved to be written to the telem.dat file at the end of the <u>following</u> day… hence, this tau is centered on the previous 72 hours (time-centering chosen to be same as for pressure).

10.2.2 pressure data: Pressure is measured 1,2, 3 or 6 times per hour depending on the schedule selected by the user. At the end of each hour the value(s) is(are) despiked and sorted. The values are then 99.73% windowed around the median, resorted, and that median value saved in a 72 element array of hourly values that span three calendar days (the data from any partial day at the beginning of the deployment are discarded). At the end of each calendar day, after the array of 72 hourly values is filled, a Godin (25h, 25h, 24h) detiding filter is applied and the detided average pressure, centered on the previous 72 hours, is written to the telem.dat file. The 72 element array is then shifted right, removing the oldest data and making room for the next 24 hourly pressure values.

10.2.3 current meter data: water speed data in rectangular coordinates (U,V == east & north components) are processed individually through the same algorithms used on the pressure data as described above. The data are detided using the same Godin (25h, 25h, 24h) filter and also centered on the previous 72 hours. U and V values are written to the on board data storage but are converted to polar coordinates when written to the telem.dat file. For acoustic telemetry the current measurement is in speed (cm/sec) and heading (compass angle, in degrees, increasing clockwise from North).

10.3   IES Schedule for PDT Operations

The IES wakes up from low-power sleep every 10 minutes and performs all data collection tasks that are scheduled.   An IES data collection day ends after the 23:50:00 data collection tasks are complete. At that time all the data collected during the previous day, currently residing in temporary RAM storage, are written to the non-volatile FLASH memory card and the previous 24 hours of travel time, pressure and current data are processed (see **IES Data Processing for File Telemetry** above) and stored in the telem.dat file along with the year-day number corresponding to the center of the preceding 72 hour period.   The de-tiding routines require three complete and contiguous calendar days of data to be collected before any data processing occurs. Hence, no processed data are stored in the telem.dat file until four 23:50 hour marks have occurred.

10.4   PDT Record Framing

The time of arrival of the marker pulse (10.0 or 11.0kHz) at the receiver is recorded and the differences between that time and the arrival times of the five following pulses (11.5, 12.0, 12.5, 10.5, 13.0kHz) are scaled to represent five data values. As depicted in the time line figures, the five pulses representing the data values delayed from the marker must always fall within specified windows. If they do not fall within these specified *time* windows the receiving software will reject them as invalid data points. The five pulses representing data values relative to the marker pulse will never overlap in time. The receiving software will start receiving a data record with the detection of the marker pulse (10.0kHz or 11.0kHz) and *must* then receive data as a sequence of pulses… 11.5kHz, *then* 12.0kHz and *then* 12.5kHz, etc… any out-of-sequence arrivals will not be accepted by the receiving software.

10.5   PDT Receiver Data Logging

Once a receiver program is invoked, the data received will be saved in an appropriate output file… **burst.dat** if converting burst telemetry data or **filet.dat** if converting file telemetry data. The data in both files are composed as records. For *burst* telemetry each record includes the sample number, the corresponding tau value, the pressure value and the speed & heading values. For *file* telemetry each record corresponds to a line in the IES's telem.dat file and includes the year-day, tau (acoustic travel time measurement), pressure, speed and heading. The converting receiver software calculates the delays between the marker pulse and each of the five following pulses and converts the delays to the appropriate engineering units as outlined in figures 10-1, 2 & 3.

10.6 Receiving: Burst PDT vs File PDT
        As stated above, the IES utilizes two modes of PDT telemetry: burst and file. The timing and the protocol of both telemetry modes is identical… the difference between burst and file telemetry is in the processing and scaling of the data prior to transmission, i.e., the resolution of the data values. The following sections describe the difference between the two data transfer modes.

10.7 Burst Telemetry Report
        Burst telemetry is primarily used as a diagnostic tool to verify that the IES hardware is operating properly after it has been deployed on the sea floor. Burst telemetry reports full data values… poor signal resolution, but no ambiguity in the value of the measurement.

        For fast evaluation of IES performance, the burst telemetry receiver software converts the travel time and the pressure data as meters of depth. For example, if the travel time measurement schedule is 4 pings every 10 minutes, the burst telemetry (if it has been activated with the ACS 'TELEM' command) will report the four travel time values, accurate to 1 meter of depth. The most recent pressure measurement will be converted to depth in meters and the same value will be reported in all four PDT burst telemetry frames. (If the pressure option is not enabled the pressure value reported will be zero in all four frames.)
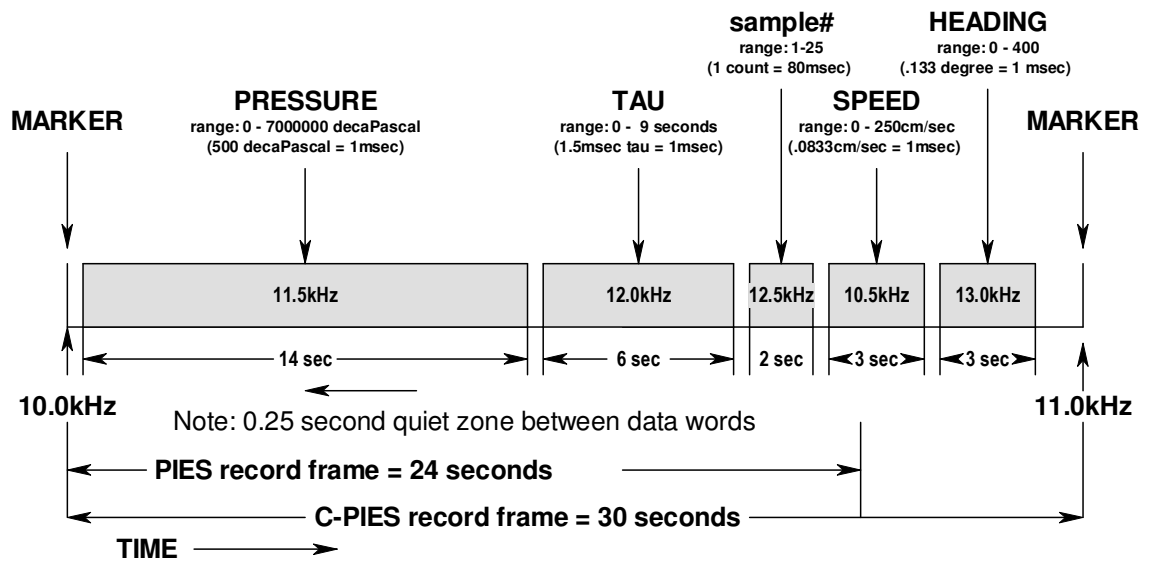

Figure 10-1   C-IES Burst Telemetry – Record Framing
Omit speed and heading values and make frame = 24 sec. for PIES telemetry

10.8 Burst Telemetry Checklist

Assuming that the IES clock has *not* reached 23:50:00 hours *four times* since the last RESET and that the IES has been launched and is on the sea floor… the following operation will determine if the IES echo detector and pressure sensor is working properly… this is **burst** telemetry:

1. *Prior* to the next travel time burst, use the Benthos DS-7000 acoustic deck unit to send the appropriate ACS 'TELEM' command to the IES. Make sure that the DS-7000 transducer extends below the keel of the ship so it is not shadowed from the IES.

2. Verify that the IES replies with the standard two ping response (see IES User's Manual, Chapter 5).

3. Connect the DS-7000 AUX connector serial cable to the COM1 port of the laptop computer. Switch the DS-7000 to **'REMOTE'** mode.

4. Using the Windows Explorer program, delete the **burst.dat** file (if it exists) in the **c:\matlab\telemetry\data** directory. Create these directories if they do not exist.

5. Start Matlab 6, release 13 or above. From the Matlab command window change to the **c:\matlab** directory and run the **PburstPDT.m** program. This will initialize the DS-7000 and the computer as a burst telemetry data receiver. Watch the DS-7000 display change as the channels are set up.

6. When the DS-7000 deck unit has completed initialization, the Matlab workspace window will display **" Waiting for marker (10.0kHz)…"** in the Matlab command window. The receiving program will remain at this point until the IES has finished its travel time measurement burst, pressure measurement and begins to transmit this information via the burst telemetry scheme.

7. Observe the Matlab command window… it should step through the detection of the four different receiver frequencies, 10.0, 11.5, 12.0, 12.5, 10.5 and 13.0kHz and loop to the next record frame… again waiting for a 10.0kHz marker pulse.

8. The received data will be converted to year-day, travel time and pressure and saved in the **c:\matlab\telemetry\data\burst.dat** file. The data will also be converted to depth and reported in the Matlab command window. Evaluate the data received, i.e., is the proper depth reported? The program converts the incoming data to sample#, depth from travel time, depth from pressure and saves the raw travel times and pressure data in a file. If the data look good, given the known water depth, send the 'CLEAR' command with the DS-7000. You can now leave the site confident that the IES is working properly. If the data are not valid, try to evaluate whether the problem is in the acoustic link (DS-7000 gain adjustment?… receiver hydrophone depth?… ship noise?) or if the IES itself is malfunctioning and collecting faulty data. If the former, make the adjustments and return to step 1 of this operation. If the problem is with the IES, wait for another burst telemetry and confirm the analysis before deciding to recover the IES for repairs.   The ship itself can be a target for the IES echo detector, so small errors in travel time on the scale of the ship's draft should be ignored. Also, the reported depth from pressure will usually be in error by ~ 10-40 meters until the pressure sensor equilibrates with the bottom temperature (requires ~20 hours).

9. If you experience false marker pulses or other acoustic signals at inappropriate times you should reduce the gain of the DS-7000 deck unit. To adjust the gain of all six channels of the DS-7000, edit the BurstPDT.m script file and change the variable "gain"… one place, at the top of the file. The default at this date (2/11/03) is "gain = 3" for all six channels.

10. Change the name of the burst.dat file to include the PIES serial number and move it to an appropriately named archive directory.

10.9 File Telemetry

File telemetry is used to transfer processed, scientifically significant data… data collected in lieu of recovering the IES to access the data. The data transfer process involves two different protocols; MSB and LSB. The MSB (most significant bits) record, similar to the burst telemetry record, reports the full data values. The resolution in MSB record values is not high enough to show scientifically significant variability but will eliminate any ambiguity in the accompanying high resolution (LSB) records.

File telemetry LSB records report the least significant bits of the daily mean values of travel time (modulo 0.5seconds), pressure (modulo 2000 decaPascals = 2 meters) and water speed (modulo 40cm/sec)… that is where the signals of interest are embedded. A single MSB record will be sent at the start of each file telemetry data block of 27 days to remove the ambiguity due to the modulo operator rollover.

To summarize, file telemetry LSB records provide optimized signal resolution, but the user must use the MSB record information to provide (add) the most significant bits for overall accuracy. The following discussion outlines the process.

File telemetry will transmit all of the data stored in the IES's telem.dat file starting at the end (most recent data) of the file and proceeding backwards in time*. **A data block transfer will start with an MSB <u>and</u> an LSB transmission of the first telem.dat record and continue with only LSB transmissions of the next 26 records (28 transmissions x 30seconds = 14 minutes) and then stop for one minute.* This pause allows time for the shipboard personnel to evaluate the data transfer and, if necessary, send the CLEAR command to stop the data transmission… allowing time for adjustments to be made, e.g., change the receiver gain settings, adjust the depth of the receiver transducer or move back to the deployment site. After the 1-minute pause and before sending the next 27 records, the IES will check to see if the TELEM command has been disabled by the CLEAR command. If the TELEM command is still active, file telemetry will continue where it left off… repeating the MSB record first and the one-minute pause every 27 records until the entire telem.dat file is transmitted.

The IES will synchronize the beginning of each data block transmission with the start of the next minute of its clock… this starts a new data block every 15 minutes (re: from the start of the first data block) for CPIES configuration.

NOTE: Telemetry for the corresponding PIES configuration proceeds the same way except takes less time: A 34 day block of data gets transmitted in [34(LSB) + 1(MSB)] x 24 secs = 14 minutes and, after the 1 minute pause, synchronizes with the 15th minute.

File Telemetry (cont'd)

If the entire telem.dat file has been transmitted, the acoustic command system is reset which clears the telemetry flag and the job is finished. Once the TELEM command has been CLEARed (by finishing the job or by a received CLEAR command), the IES will return to its data acquisition schedule. Any measurement bursts that would have been scheduled during the file telemetry operation do not take place and their travel time and pressure data values will be zero. [Note: For subsequent in situ data processing, the IES discards these zero values.]

The IES's daily data processing session, which updates the telem.dat file, occurs after the day's last data acquisition tasks are complete, i.e., after 23:50:00. The file telemetry session must not interfere with this essential function, so the file telemetry process is locked out after any data block is finished after 23:30:00, i.e., the telemetry is locked out for 15 to 30 minutes prior to 00:00:00. In other words, if a file telemetry session is in progress and the 1 minute pause occurs between 23:30:00 and 00:00:00, the telemetry session will not resume after the pause. However, the file pointer will be saved and if the TELEM command is re-sent after the 00:00:00 tasks are complete, the file data telemetry will continue from the saved point in the telem.dat file.

If the TELEM command is disabled with the CLEAR command, the file pointer will be saved for 24 hours (re: the start of the telemetry session). If the TELEM command is re-sent within this 24 hour period, the data transfer will continue from where it left off, otherwise (after 24 hours) the pointer will be returned to the end of the telem.dat file and the most recent data will again be transmitted first. Regardless of the position of the file pointer, the telem.dat file will remain in place with additional data being appended each day. ***Since the file telemetry access is 'last-in-first-out', if you return months later, you only have to collect the data accumulated since the most recent telemetry collection.***

The telem.dat file is created when the system initially starts its mission. At that time two records are written to the file; a time stamp record and a "telemetry file empty" record which has the same format as a data record but the values are: year-day=375, tau=0 and pressure=0. Since the telemetry file is read backwards, this record will flag the end of the telemetry file data. With this file it is easy to see the end of the telemetry session when the data are being plotted as they are received.

File Telemetry (cont'd)
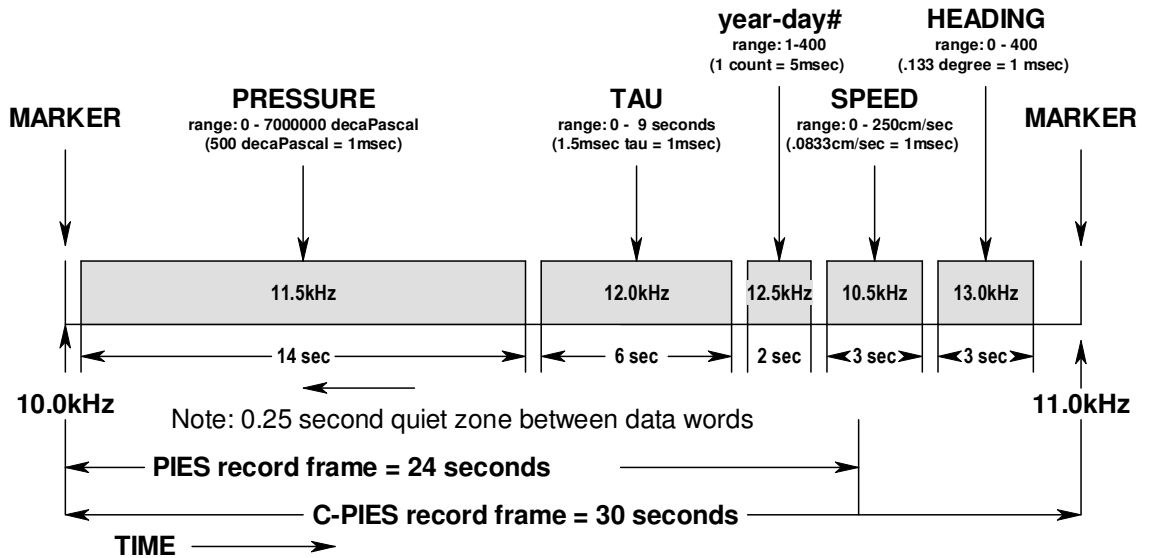
Figure 10-2   C-PIES File Telemetry – MSB Record Framing
(Omit speed & heading values and make record frame = 24 secs. for PIES telemetry)
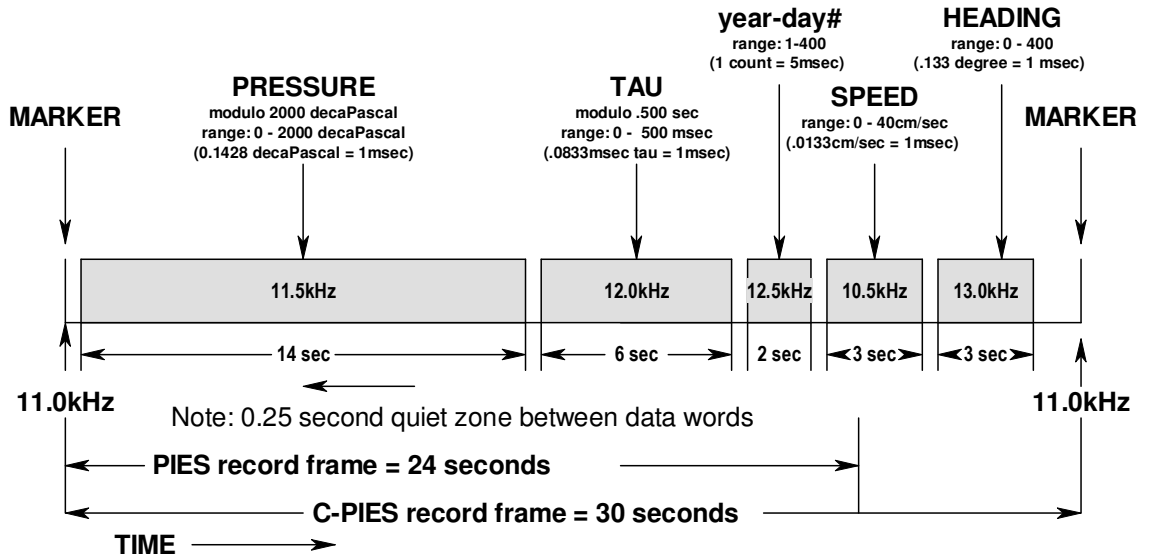
Figure 10-3   C-PIES File Telemetry – LSB Record Framing
(Omit speed & heading values and make record frame = 24 secs. for PIES telemetry)

Figure Notes:
        All values will be plotted individually in Matlab graphics windows as the FilePDT program runs.
The horizontal axis will be the number of marker pulses that have been received. Any missing data will
leave a gap in the respective plot… missing markers cause loss of one day's values for all variables, but the
plot continues to the next day's values without a gap.

10.11 File Telemetry Checklist

Assuming that the IES clock has registered 4 midnights (23:50:00 = end of data collection day) since the last RESET and that the IES has been launched and is on the sea floor. The following operation will collect the daily mean values of travel time and pressure from the IES telemetry data file… this is **file** telemetry:

1. *Prior* to the next travel time burst, use the Benthos DS-7000 acoustic deck unit to send the appropriate ACS **'TELEM'** command to the IES.
2. Verify that the IES replies with the standard two ping response (see IES User's Manual, Chapter 5.
3. Connect the DS-7000 serial cable to the COM1 port of the receiver laptop computer. Switch the DS-7000 to '**REMOTE**' mode.
4. Using the Windows Explorer program, delete the Cfile.dat or Pfile.dat data files (if they exist) in **c:\matlab\telemetry\data**.
5. Start Matlab 6, release 13 or above. From the **c:\matlab\telemetry** directory run the **CFilePDT.m or PFilePDT.m** program. This will initialize the DS-7000 and the computer as a telemetry file data receiver. Watch the DS-7000 display change as the channels are set up.
6. When the DS-7000 deck unit has completed initialization, the program display will have stopped at the "**Waiting for marker (10.0 or 11.0kHz)…**" line. The receiving program will remain at this point until the IES has finished its travel time measurement burst, pressure measurement (if scheduled) and begins to transmit the data in the IES telem.dat file.
7. Observe the Matlab command window… it should step through the detection of the six different receiver frequencies, 11.0, 11.5, 12.0 and 12.5kHz and loop to the next record frame… again waiting for a 11.0kHz marker pulse.
8. The received data will be plotted in a Matlab graphics window. Evaluate the data received, i.e., is the waveform smooth?… are the data changing appropriately? This program converts the incoming data to year-day count, travel time in seconds (modulo 0.500), pressure in 10Pa (modulo 2000) and saves the raw timing results in file **c:\matlab\telemetry\data\Cfile.dat**. (or PFile.dat for PIES)
9. If the data look reasonable, let the receiver program run until the entire IES telem.dat file is transmitted. If the data do NOT look good, wait for the one minute pause in the telemetry transmission (every 15 minutes, or 27 records (34 for PIES)) and send the 'CLEAR' command with the DS-7000 to halt the telemetry transmission. Evaluate potential problems (DS-7000 gain adjustment?… receiver hydrophone depth?… ship noise?), make the adjustments and return to step 1 of this operation.
10. To adjust the gain of all six channels of the DS-7000, edit the **CFilePDT.m** script file and change the variable "gain"… one place, at the top of the file. The default at this date (2/11/03) is "gain = 3" for all six channels.
11. Change the names of the Pfile.dat or Cfile.dat files to include the PIES serial number and move them to an appropriately named directory.

Additional Telemetry Operations Notes

10.11.1 Telemetry Session Interrupt – Saving the File Pointer
   It may become necessary to interrupt a file telemetry session before all of the desired data have been received. This may occur because the ship has drifted too far from the site for reliable reception, the acoustic receiver needs adjusting or weather related issues dictate a pause in telemetry operations. In any case, a provision has been implemented to pause a telemetry session, save (for 24 hours only) the position in the data file and restart the transmission from the saved position. This works as follows:
1.   Once file telemetry has been initiated the data transfer will pause periodically as outlined in previous sections to allow the operator to stop the transmissions (send the CLEAR command). If the telemetry session is stopped, the file pointer will be saved for 24 hours from the start of the *initial* transmission.
2.   If the TELEM command is re-sent within the 24 hour period, the data transfer will continue from the saved file position.
3.   If the entire data file is transmitted, the file pointer will be reset to the end of the file and the 24 hour timer will be cleared. The next TELEM command will initiate a new session.
4.   If a session is paused multiple times, file pointers will be saved only during the 24 hours from start of the session. After 24 hours, any subsequent TELEM command will initiate a new session with the file pointer at the latest data. In other words, the 24 hour timer *does not* get restarted with each TELEM command.

10.11.2 Telemetry Session Interrupt – Pause @ 2330 hours (for 15-30 minutes)
 This feature is outlined in a section above.

10.11.3 Telemetry After Failed Release
            In standard operations, acoustic telemetry file data transfers will occur mid-deployment… typically there will not be a telemetry session immediately prior to recovering the instrument. However, a provision has been added to insure that, in the unlikely case that the IES does not leave the sea floor after the release command has been sent, the data can be recovered even if the instrument is not.

Instrument programmed (firmware) *prior to* March 2004:
            After the IES release command has been sent and acknowledged, the instrument initiates a 4-second acoustic tracking beacon that, for IESs programmed prior to March 2004, continues until the IES is turned OFF or RESET. The IES enters a low power state and can no longer accept acoustic commands. Telemetry is not possible.

Instruments programmed (firmware) *after* March 2004 follow these steps:
1. After a RELEASE command has been acknowledged and the burn-wire anchor release mechanism has been activated, the 4-second beacon will continue until the end of the third full hour (re the IES clock).
2. At the beginning of the fourth hour the 4-second beacon will cease and the IES's acoustic command subsystem (ACS) will be reset, enabling it to accept further commands. The burn-wire anchor release mechanism will NOT be reset and will continue its attempt to release the IES from its anchor.
3. The IES will wake up every ten minutes and if it detects that the ACS has received a TELEM command it will start a file telemetry session as outlined in previous sections.
4. If file telemetry continues until the entire data file is transferred, the IES will restart the 4-second beacon, enter a low power state and NOT accept any further ACS commands. The 4-second beacon will continue until the batteries are exhausted.
5. If, when the IES wakes up, it detects a RELEASE command, it will restart the 4-second beacon, reset the three hour timer and loop back to step 1 above.

Chapter 11   Acoustic Tracking & Telemetry – At Sea Operations

11.1 Telemetry Cruise Preparations

This chapter is divided into three parts in the form of task lists that should be performed:

1. Prior to the cruise – as part of cruise preparations
2. Just prior to arriving at the IES deployment site
3. At the start and during the telemetry operations

11.1.1 Hardware & Software Requirements (part of cruise preparations)

The following **_hardware_** is recommended to conduct IES acoustic tracking & telemetry operations:

➢ Benthos DS-7000 Acoustic Transceiver configured for eight receiver channels and programmed to transmit URI-GSO command codes (special order from Benthos).
➢ Appropriate cable/connector to interface with the DS-7000 Auxiliary Port RS-232 communication output.
➢ Data Tap Module (B&B Electronics Model No. 9PCDT) with appropriate RS232 cables as shown in Figure 11-1.
➢ Two computers: one for direct RS-232 communications with the DS-7000 and one for eaves-dropping on these communications to monitor incoming signal strength.
   NOTE: We set up the second laptop for double duty: TRAX4 display and telemetry noise monitoring. However, this creates a problem; the TRAX4 *must* operate in MS-DOS mode, so for greatest convenience, you need to find an RS-232 terminal emulation program (like PROCOMM) that will also run in MS-DOS mode.

The following **_software_** is recommended to conduct IES acoustic tracking & telemetry operations:
  Note: The Matlab elements (**.m files) on this list are available from URI-GSO without charge.

➢ Matlab Version 7.01 version 13 or higher (available from MathWorks. Inc.)
➢ DS-7000 telemetry setup, receive and data logger:
   o PPDTb.m – Receiver/logger for PIES burst & file telemetry
   o CPDTb.m – Receiver/logger for C-PIES burst & file telemetry
   o PPlotPDT.m – Data display for PIES file telemetry
   o CPlotPDT.m – Data display for C-PIES file telemetry
   o TelemPlot.m - Subroutine for both of the display programs
   o Telem_plot.m – Additional subroutine used by TelemPlot
   o RenamePDT.m and DeletePDT.m – Data file management utilities
   o cf.m – DS-7000 configuration utility (closes any open ports & files for restart)
   o RS-232 terminal emulator (Hyperterminal, Procomm, etc.)
➢ DS-7000 acoustic tracking:
   o TraxSet.m – Sets up the DS-7000 for acoustic tracking mode
   o TRAX4 Software Package – Available from Chaplin Marine Instruments (www.cmari.com).
   o DS-7000 AUX port adapter (available at cmari.com)
   o TRAX4 converter module (available at cmari.com)

11.1.2 Shipboard Equipment Setup (part of cruise preparations)

1. Assuming an MS-Windows platform, create your project and data folders. For example, if you name your project NEGoMex2005, you would create the folders: c:\NEGoMex2005\telemetry\data

2. Copy all of the Matlab *.m files listed above into the folder …\telemetry

3. In Matlab701/toolbox/local, edit startup.m so Matlab.exe will go to your project path when it is started:

      for our example project (NEGoMex2005), you would add the following to startup.m)
          cd \
          cd NEGoMex2005\telemetry\

4.   With the Matlab editor, go to the bottom of the receiver files (PPDTb.m & CPDTb.m) and change the project name in the paths of the various data destinations.

5. Depending on the depth of the work area, change the default GAIN value (see the top of the receiver files). Use the following rule of thumb:

GAIN	DEPTH
1-2	1-2 km
2-3	2-3 km
3-4	3-4 km
4-5	>4 km

  Note: This is just the *default* GAIN… it can be changed at startup and during operations.

6.   With the Matlab editor, go to the display files (PPlotPDT.m & CPlotPDT.m) and change the project name in the path of the data source. Note: Both of these programs use TelemPlot.m and Telem_plot.m which do not require any data path modifications.

7. With the Matlab editor, go to the telemetry utilities RenamePDT.m and DeletePDT.m and change the project name in the paths to your data folder sources and destinations.

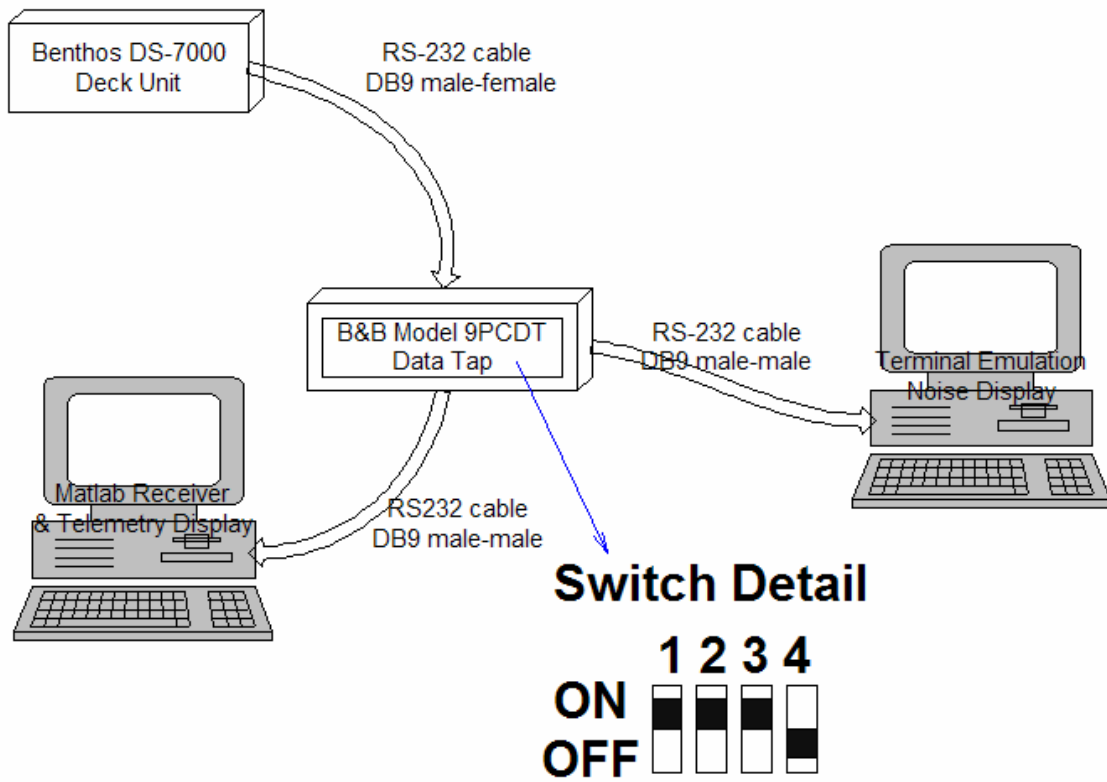8. Set up your hardware as shown in Figure 11-1.

Figure 11-1 IES Acoustic Tracking & Telemetry Hardware Setup

11.2 Preparations Prior to Individual Sites

Note: The following operational procedures assume that you are using the Benthos DS-7000 over-the-side acoustic transducer to communicate with the IES. This means that you are *not* able to move the ship while the transducer is in the water. If you are using the ship's hull-mounted transducer and *can* move during IES operations, you can ignore the instructions dealing with ship's drift and just keep the ship positioned at the site (providing the ship's propulsion system is not too noisy).

URI-GSO has developed a form to log a telemetry session… see section 11.2.1.   Make a copy of this form for each site to be visited.   After you fill out the top portion of the form (prior to arrival at the site) you will know how much time the telemetry operation will require. It is important to know this information if you plan on drifting during the data transfer… you may have to make multiple passes if the telemetry file is very big or the drift rate is high enough to push you out of range (>1.5 mile) before the process is complete.

1. Put the DS-7000 in REMOTE mode and run Traxset.m to set up the DS-7000 for 12.00kHz listening on channel 1 (all other channels will be OFF). The output power will be set to maximum (7) and the GAIN of channel 1 will be set to maximum (8)… these are default values and should be changed to suit the conditions (see below).

2. After arriving at the IES site, make sure the ship's propellers are stopped and lower the DS-7000 transducer to a depth that is below the ship's keel. Monitor the ship's drift speed and direction during the following operations.

3. Confirm that the instrument is, in fact, still there by:
➢ Listen for the IES sample and note the time of the 1st ping of a burst. This will indicate the drift of the IES clock and hence, tell you when telemetry transmissions will start & pause.
➢ Send the CLEAR command and listen for the 2-ping response. This confirms that the IES acoustic command system (ACS) is working properly.

Note: If you have problems with the IES accepting commands, especially in shallow (<2km) water, lower the output power. To change the DS-7000 output power, press the MODE SELECT button until you get to SETUP mode. Then press MISC (the ^ arrow) and you will arrive at a menu that will allow you to change the output power. (*Note: The DS-7000 gain steps are not in dB but in some Benthos scale???) (Important note: The internal battery of the Benthos DS-7000 must be disconnected for this to work… if the battery is connected the output power is always max… a bug in the DS-7000 design!).* Usually lower output power (1-3) and moderate gain (4-5) work best.

4. Let the ship drift until you have a clear idea of the effects of wind and current. Once you know this information, you can determine if you can collect all the data in one pass or will require multiple passes. Move the ship to a position that will allow maximum exposure time over the IES site during the telemetry transfer. For best results, keep the ship within 1.5 miles horizontal of the target site.

11.2.1 Telemetry Log Form

Print a copy of the following page for each scheduled telemetry site and fill in the appropriate section of the form prior to arrival at the site.

Inverted Echo Sounder - Model 6.2A Telemetry Log

Fill out this section prior to site: **IES S/N**

Project/Site_____   _____

Year-day # _____

Operator:_____   **Date:** _____

Warning: no telemetry between 23:30 - 00:00 GMT = = ___:30 – ___:00 LOCAL

  PIES Firmware rev: _____   **cPIES Firmware rev:**_____

  TELEM cmd: _____   **RELEASE cmd:** _____

Deployed (yr-day) _____   **Total # of records [(yr-day)-(deploy-day)-3] =**_____

Site depth _____m   **Tau =** _____sec.   **Yr-day range:** _____

Telemetry duration: PIES: (#records)/34 x 15 minutes = _____min.
                    cPIES: (#records)/27 x 15 minutes = _____min.

Arrive at site @ _____ GMT   **1st ping @** _____ GMT

CLEAR cmd: 2-ping reply? _____ y/n   Drift: _____ **Heading:** _____

Position re site: start _____   **finish** _____

TELEM cmd sent @ _____ GMT   **ACS replies @** _____ kHz

Start telemetry @ _____ GMT   **DS-7000 GAIN (Matlab setting)** _____

Conditions/modifications during transmission:

CLEAR cmd required? ___ y/n (required ONLY if entire telemetry file was NOT transmitted)
Routine IES tau sampling resumed @ 1st ping _____ GMT

Simultaneous CTD? _____ y/n   CTD data file name _____

Tau rollovers? (y/n) ___   Data quality _____
Press rollovers?(y/n) ___   Data quality _____
C-PIES only => Speed Data Quality _____

NOTES:

11.3 Starting and Maintaining a Telemetry Session

1. Two Matlab sessions, running simultaneously on a single computer, are required; one to receive and log the data and the other to plot the data. Start the receiver program first. The plotter program can be started at any time… it will plot whatever is in available in the data file.

2. At times, if a data value is missing or does not make any sense, the plotting program will stop and return to the Matlab prompt. If this happens, simply restart the display program (PPlotPDT or CPlotPDT).   No data will be lost, however, a gap may appear in the plot. *Note: The horizontal index number that appears on the plot is an indication of the number of valid data frames that the receiver has detected… it is not an accurate indication of the number of frames that have been transmitted by the IES or when the transmission pauses will occur. The best indication of when pauses will occur is to note the year-day number at the start of the transmission and monitor the yr-day number progression… CPIES will pause every 27 days and PIES will pause every 34 days.*

3. If you get lots of MSB markers, that's a sure sign that the gain is too high. Simply enter <ctrl+c> to stop the program then run cf.m to close the comm port. Restart the receiver program and enter a lower gain value.

4. On the noise indicator laptop, the ideal gain settings will show 3-4 returns for every data ping. More than that; reduce the gain… less than that; monitor for missed pings. Use the lowest gain possible to minimize false signals. *Hint: A gain of 2-3 will work at a range of 1.5 mile at 3km depths in calm seas.*

5. Be aware of the acoustic influences on your transducer, e.g., depth sounders, altimeters, bow thrusters, ship-positioning systems, water hoses running over the side, dolphins, air bubbles from wherever, etc. Use the noise monitor computer display to detect & minimize these noise sources*. For example: We found during KESS 2005 on the R/V Revelle, while using the ship's transducer, air bubbles from the props would block acoustic signals when the ship was backing down.*

Chapter 12   Aanderaa Acoustic Doppler Current Sensor Option

The IES Model 6.2 can be configured to measure horizontal current velocity (i.e., speed and direction) at a single point up to 50 meters above the sea floor. This feature has been developed and field-tested to 6000-meter depth.

12.1   General Description

An Aanderaa Model 3820R Doppler Current Sensor (DCS) can be added to the IES Model 6.2 as shown in Figure 12-1. This sensor head is the same device used in Aanderaa's Model RCM11 Current Meter. For this application, it has been modified for remote control and data storage.
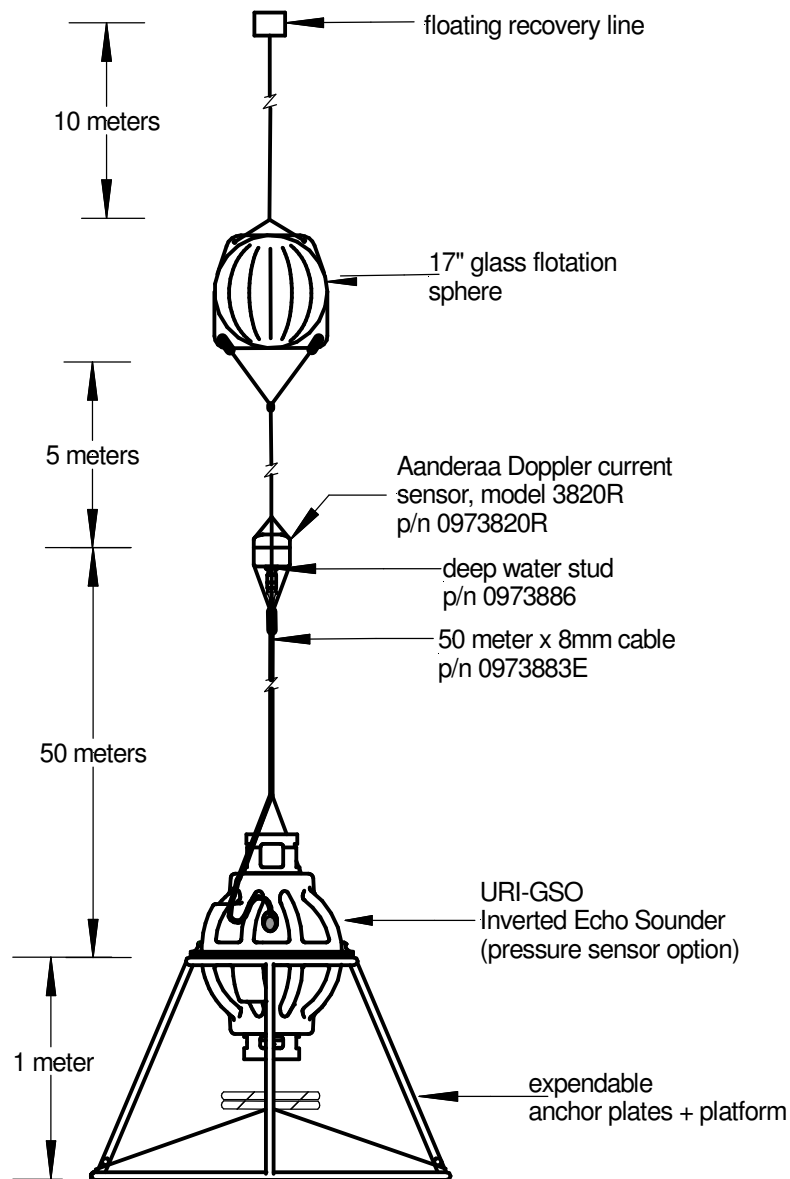
Figure 12-1   IES with Doppler Current Sensor (DCS) – Deployed View

General Description (continued)

An auxiliary RS-232 communications port, standard on the Model 6.2 circuit board, provides an interface with any sensor that conforms to 'smart sensor' communications protocols… in this case, the Aanderaa DCS. Power to the DCS is provided by the IES battery pack and switched via the auxiliary COM port, through a glass sphere bulkhead connector, to the 50-meter cable.   Current measurements are synchronized with the IES's travel time and pressure measurements and all scheduled by the IES real time clock. DCS data are stored on the IES flash memory card in a format compatible with the IES travel time and pressure measurements.

The Aanderaa model 3820R provides velocity, heading, tilt and temperature sensors. The device, once switched ON by the IES, controls its own sampling ensemble. Data are output in engineering units (cm/sec, degrees heading, etc.) after a number of measurements are averaged.   Further DCS details can be found in Aanderaa's "Operating Manual - Doppler Current Sensor 3900R".

12.2 Doppler Current Sensor Specifications

Current Speed: (from vector averaged velocity)
Range: **0 – 300 cm/s**
Resolution: **0.03 cm/s**
Accuracy:
       Absolute: **±0.15 cm/s**
       Relative: **±1% of reading**
       Statistical precision: **0.5 cm/s (standard deviation)**

Current Direction: (vector averaged)
Range: **0-360° magnetic**
Resolution: **0.35°**
Accuracy:
    ±5° for 0-15° tilt
    ±7.5° for 15-35° tilt

Temperature:
Range: **-10 to +43°C**
Accuracy: **±0.08°C**
Resolution: **0.01°C**

Tilt:
Accuracy: **±1.5°**

Compass:
Accuracy: **±3°**

RS-232 output signal: **4800, 8, N, 2**

Acoustic Frequency: **2MHz**

Acoustic Power: **25W in 1ms pulses**

Beam Angle: **±1° (main lobe)**

12.3 DCS Setup Menu

The DCS can be configured, scheduled and tested via the IES User's Menu interface. When the DCS option is installed in the Model 6.2 IES, an additional setup menu will become available from the general mission setup menu… see selection 'K' in Figure 12-2.
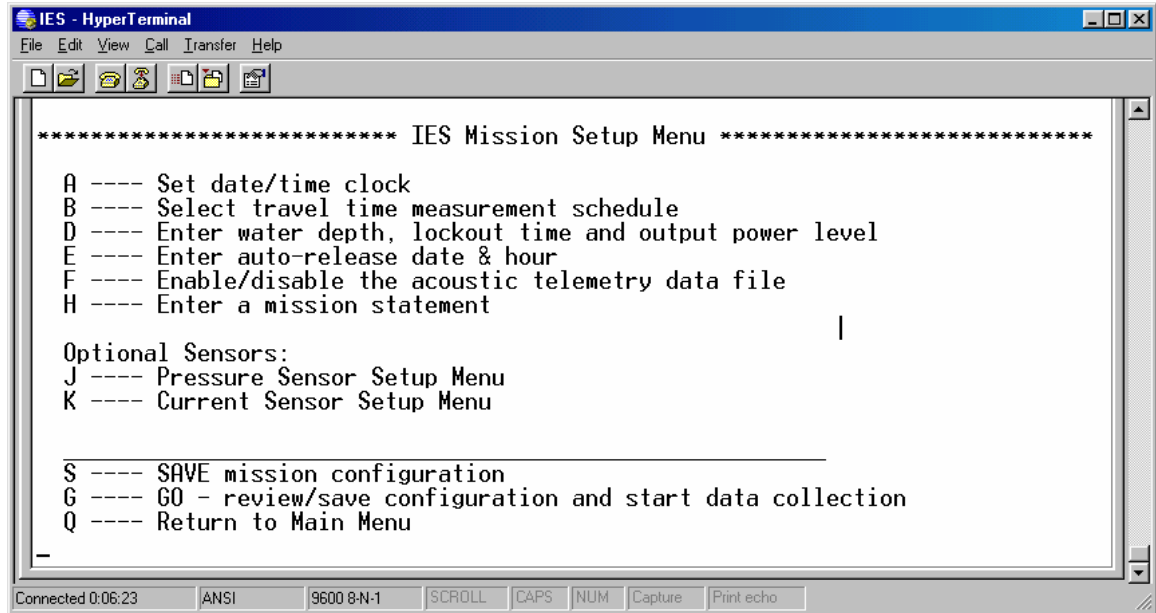

Figure 12-2 C-PIES Mission Setup Menu - Note Options List, Selection 'K'

Selecting 'K' on the IES Mission Setup Menu brings you to the DCS Setup Menu.
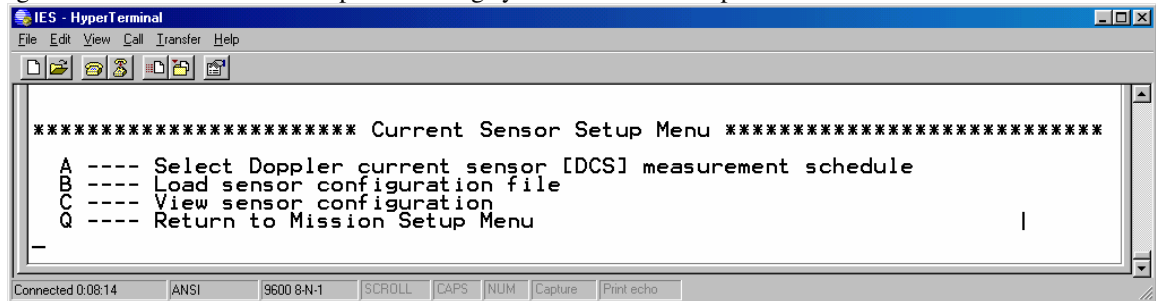
Figure 12-3 C-PIES DCS Setup Menu

The DCS Sensor Setup Menu allows the user to:
 ➢ Schedule current measurements, offering the same options as the pressure sensor measurements, i.e., every 10, 20, 30 or 60 minutes. The schedules for pressure and current can differ. The DCS measurements can also be disabled.
 ➢ Modify the DCS measurement parameters. The IES transfers a set of operating parameters from a configuration file (A*.cfg), stored on the IES flash card, to the non-volatile memory of the DCS. This file is composed at URI-GSO and should not be modified by the user without contacting an applications engineer.   *Warning: There are many configuration options listed in the Aanderaa DCS 3900R Operating Manual that are NOT compatible with the IES application.*
 ➢ View/Confirm the DCS measurement parameters. The DCS measurement parameters stored in the sensor are retrieved and displayed.

12.4   The DCS Configuration File

As of this date (July 2005) the DCS configuration file for IES Model 6.2 C-PIES is named A3.cfg and reads as follows:

>   **Set_Property_Averagebase(300)**
>   **Set_Property_Current_Type(Rectangular)**
>   **Set_Property_Compensation_Compass(On)**
>   **Set_Property_Compensation_Tilt(On)**
>   **Set_Property_Compensation_Upstream(On)**
>   **Set_Property_Output_Comprehensive()**
>   **Set_Property_Output_Format(Engineering)**
>   **Set_Property_Output_Polled(Off)**
>   **Set_Property_Pingrate(1200)**

The above Set commands, unless otherwise noted, stores data to the DCS flash memory. The flash memory cannot be overwritten more than 10000 times, hence, these commands are only used during setup and are not used during data logging operations.

A brief description of each command follows. For a comprehensive description of these and additional commands refer to the Aanderaa Operating Manual for the Doppler Current Sensor 3900R.

12.4.1   Set_Property_Averagebase(300)   Set the number of pings that will serve as the base for a current speed and direction measurement. The Averagebase can vary between 1 and 300 ping sets. One ping set consists of two pings. The Averagebase will also affect the interval between each output in non-polled mode.

12.4.2   Set_Property_Current_Type(Rectangular) Sets whether the output is reported in polar coordinates (speed/direction) or rectangular coordinates (north/east) format.

12.4.3   Set_Property_Compensation_Compass(On) Sets whether the estimated current should be compensated for compass readings or not. "On" implies that currents are reported in coordinates relative to magnetic North.

12.4.4   Set_Property_Compensation_Tilt(On) Sets whether the estimated current should be compensated for tilt readings or not. "On" implies that the true horizontal components of current are calculated.

12.5.5   Set_Property_Compensation_Upstream(On) Sets whether the DCS should sense and compensate for upstream currents (i.e.,the DCS will ping *toward* the current flow). If this property is OFF, the DCS will ping its transducers in a predetermined pattern (TR1 -> TR2 -> TR3 -> TR4 -> TR1, etc.)

12.6   The DCS Configuration File (cont'd)

12.6.6   Set_Property_Output_Comprehensive() The output will include the following when the DCS has this property set:
- ➢ Current speed and direction
- ➢ Water temperature
- ➢ Signal strength
- ➢ Compass
- ➢ Tilt
- ➢ Ping count

12.6.7   Set_Property_Output_Format(Engineering) Specifies the output converted to engineering units, e.g., cm/sec as opposed to raw data values.

12.6.8   Set_Property_Output_Polled(Off) Sets whether the DCS results must be polled (requested) or automatically output when available. In non-polled mode, the DCS will collect as many pings as the averagebase is set to. When the ping sets are collected, the DCS will calculate and output the current values. While calculating and outputting the result, the DCS will halt the ping generator. This means the DCS will halt for about 1 second each time it outputs data.

12.6.9   Set_Property_Pingrate(1200) Sets the ping rate in pings/minute. If Pingrate = 0, the ping is manual, i.e., must use the Do_Ping() command. The ping rate can be between 4 and 1200 pings per minute. The ping rate has a resolution of 250useconds. The current drain on the battery is a function of ping rate as follows:

Current drain = 5mA x ping rate, (pings/sec)

Thus, for pingrate = 1200 the battery drain during current measurements = 5 x 1200/60 = 100 mAmperes

---

> *Repeat Warning: The above commands should not be modified without consulting an instrumentation development engineer at the University of Rhode Island – Graduate School of Oceanography*
> *Tel: 401-874-6505.*

12.5 DCS Testing With the IES

When the DCS option is installed in the Model 6.1E IES, an additional test selection will be added to the general self-test menu… see selection 'E' in Figure 12-4.


```
🌊 IES - HyperTerminal                                                    _ □ ×
File  Edit  View  Call  Transfer  Help

 ██  ██  ██  ██  ██

*********************** IES Self Test Menu ***********************

   A ---- Ping Test: 10 pings at programmed output level (4 sec.rate)
   B ---- Travel Time Test: a single TT measurement
   C ---- Precision frequency reference test -- measure on CF1, pin 35
   D ---- Pressure sensor test: a single P&T measurement pair
   E ---- Doppler current sensor test: a single DCS measurement
   F ---- RTC Clock Freq Test: a single clock offset measurement
   G ---- Output Power Test: accurate with ITC 3431B transducer only
   H ---- Check memory card
   J ---- View Engineering Data
   K ---- Release Relay Test -- ON for 30 seconds             |
   Q ---- Return to Main Menu

 _

Connected 0:08:31        ANSI        9600 8-N-1    SCROLL  CAPS  NUM  Capture  Print echo
```
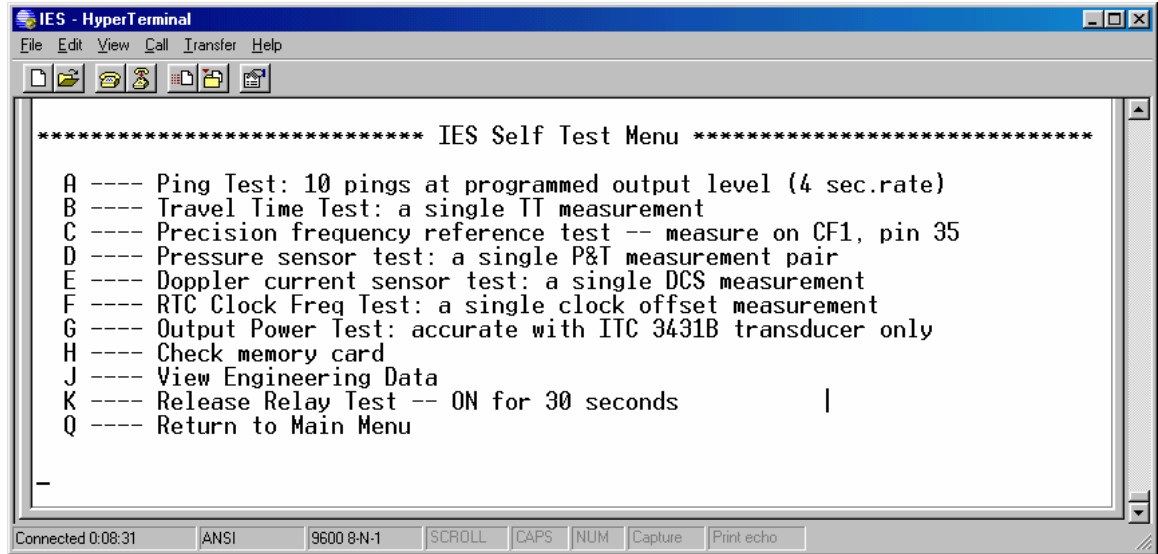
Figure 12-4 C-PIES Self Test Menu - Note Selection 'E'

Selecting 'E' on the Self Test Menu will initiate a single DCS measurement. This takes about 40 seconds and the data record will be displayed in the following format (when the DCS is configured as outlined in the previous section):

12.6 DCS data record:
<LF>yr/mo/da<space>hr:min:sec<TAB>s/n<TAB>val1<TAB>val2……<TAB>val8
field key:

s/n	DCS serial number
val1	current speed, North component, cm/sec
val2	current speed, East component, cm/sec
val3	water temperature, °C
val4	signal strength, in dB re 1023 (val = $20*\log_{10}$(raw value/1023))
val5	compass direction, degrees magnetic (0 when x-axis north)
val6	tilt North, degrees (tilt toward the north)
val7	tilt East, degrees (tilt toward the east)
val8	ping count, 0-300 (number of ping sets used in one average)

Notes: All data values are in ASCII text. Each record is written on a single line with a time stamp as shown.

12.7 DCS error record: This is the only error message available and indicates a missing or short data record. It usually indicates that there is no response from the DCS sensor.

<LF>yr/mo/da<space>hr:min:sec<space>********** NO DCS DATA AVAILABLE **********

The test described above will indicate the general functionality of the DCS but does not indicate the proper operation of the Doppler flow sensor electronics unless the sensor is in a calibrated flow tank or has a test unit attached. A DCS testing device is available from Aanderaa Instruments. Test Unit 3731 clamps over the sensor head and simulates current speed and direction. See Anderaa's web site http://www.aanderaa.com and datasheet #D320 for further details regarding this test device.

12.8 C-PIES Energy Budget – Battery Requirements

With the ping rate at 1200 and the IES measuring current every 10 minutes, the DCS adds 6.0 mA to the average current drain from the IES 7.0Volt system battery. This is in addition to the requirements for standard IES data acquisition.

Refer to the IES Model 6.1E User's Manual, Chapter 3.3 for a chart that assists in the battery life calculation. The C-PIES system battery capacity is 240 Ampere-hours… this capacity is not shown on the chart but, since the calculations are ratio metric, you can use the 120Amp-hr scale to scale your calculation. For example: In the example shown in Chapter 3.3, the average current drain is 3.2 mA. Adding 6.0 mA for the DCS, the average drain becomes 9.2 mA. If we divide this in half (4.6 mA) and reinterpret the 120 Amp-hr scale to be a 240 Amp-hr scale, we see that we can get about 3 years with a 240 Amp-hr battery. Of course you can get a full 5 years by measuring current every 20 or 30 minutes.

12.9 The C-PIES mooring assembly

As shown in Figure 1-1, the C-PIES requires a special mooring platform to avoid affecting the IES pressure gauge sensing the tilt of the 50-meter mooring line. This is the same platform used for standard IES deployments where the bottom current could exceed 35 cm/sec. The platform is made of uncoated steel and weights about 65 lb (30 kg). The additional iron anchor (100 lb or 45 kg) is required to firmly seat the IES in the mooring stand after the assembly has landed on the bottom. Both the platform and the anchor are left behind when the C-PIES is released from the bottom. The total system weight is about 270 lb (123 kg) in air. Without the anchor/platform, the system has about 65 lb (30 kg) of buoyancy in seawater.

12.10 Deploying the C-PIES

Attach the mooring anchor/frame to the IES as shown in Photo 12-1. The C-PIES assembly is deployed recovery line first with the ship underway at about 1 knot. Let the recovery line, floatation sphere, DCS sensor and connecting cable stream behind the ship, holding the anchor/frame/IES on deck, attached to the crane. When these components are streaming behind the ship, lift the *frame* with a quick-release hook as shown in Photo 12-2 (do *not* lift from the IES), lower the C-PIES to the water surface and trip the quick-release hook.   The mooring will fall to the seafloor at about 72 meters/min.

12.11 Post-Deployment Confirmation of DCS Operation

The standard Model 6.1E IES is equipped with an acoustic telemetry feature that allows the user to confirm proper operation of data acquisition electronics *after* the system is on the seafloor. (See Model 6.1E IES User's Manual, Chapter 8.1.4) When the DCS option is installed, there will be an additional 3-ping (@ ½ sec rate) signal from the C-PIES *after the standard telemetry pings* if the DCS data is *NOT* available, i.e., if the current meter is not responding. In other words, if you do *NOT* hear a three-ping signal after the standard 2-ping telemetry signal, you can assume that the DCS is operating properly.

12.12 C-PIES Recovery

The recovery of the C-PIES assembly is identical with that of standard IES except that it will rise from the sea floor at about 92 m/min. When lifting the C-PIES aboard the ship, the lifting line should be hooked on the lifting line of the IES.   *DO NOT LIFT THE C-PIES ON BOARD USING THE DCS SENSOR CABLE!*

Photo 12-1 Anchor/Platform Attachment to C-PIES

Photo 12-2 Lifting Point for C-PIES Deployment

Appendix A

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Handling Procedures for VITROVEX
Glass Instrument Housings.

You have purchased a concept in deep sea instrument housings which is completely different to the common metal or synthetic materials. After a period of familiarisation, you will highly appreciate the host of advantages that glass offers for many applications.

It is necessary to emphasise the differences in handling the glass cylinders and spheres.

1. Glass is sensitive to impact, always handle with best possible care. Plastic protective covers should be installed. Using Perspex maintains transparancy.

2. Glass housings are only strong against PRESSURE, not tension or shear or torsion. Do not install in instrument platforms where they are subjected to such forces. Thermal shock is to be below 100°C.

3. Evacuation of the housings is recommended for three reasons:

. settle the parts firmly.
. avoid inside condensation,
. avoid excess inside pressure when the instrument is heated up, for instance when it is exposed to sunlight. Air would try to seep out and then cause a leak in the seal.

4. No O-rings are used. NEVER USE GREASE or OIL as a sealing aid. Surfaces must be meticulously clean. Wipe with residual free solvent (e.g. toluene) and do not touch again before closing.
Sealing is done glass-to-glass with outside sealing strip. Sealant strip is mechanically stabilised with sealant tape.

5. For installing and fixing instruments inside, it is suggested that glass glues are used. They are commercially available, they reliably bond metal or synthetics to glass.

We are glad to support you in special engineering questions.

Sealing Material

Sealant Strip   TERROSTAT VII Iso.Butylrubber, (grey) 20x2mm (for frequent opening and closing), or
TERROSTAT 81 Butylrubber (black), 20x2 mm (for permanent sealing)

Sealant Strip   3M SCOTCHRAP 50
50,8x0,254 mm, 30,4 m long

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University of Rhode Island
Graduate School of Oceanography

Title: IES - PREAMP & OUTPUT DRIVER

Size: B

Number: IES6.2

Design: Gerry Chaplin

Rev: A

Date: Feb 24, 2005

Drawn by: Chaplin

Filename: IES62_A.sch

Sheet 2 of 6

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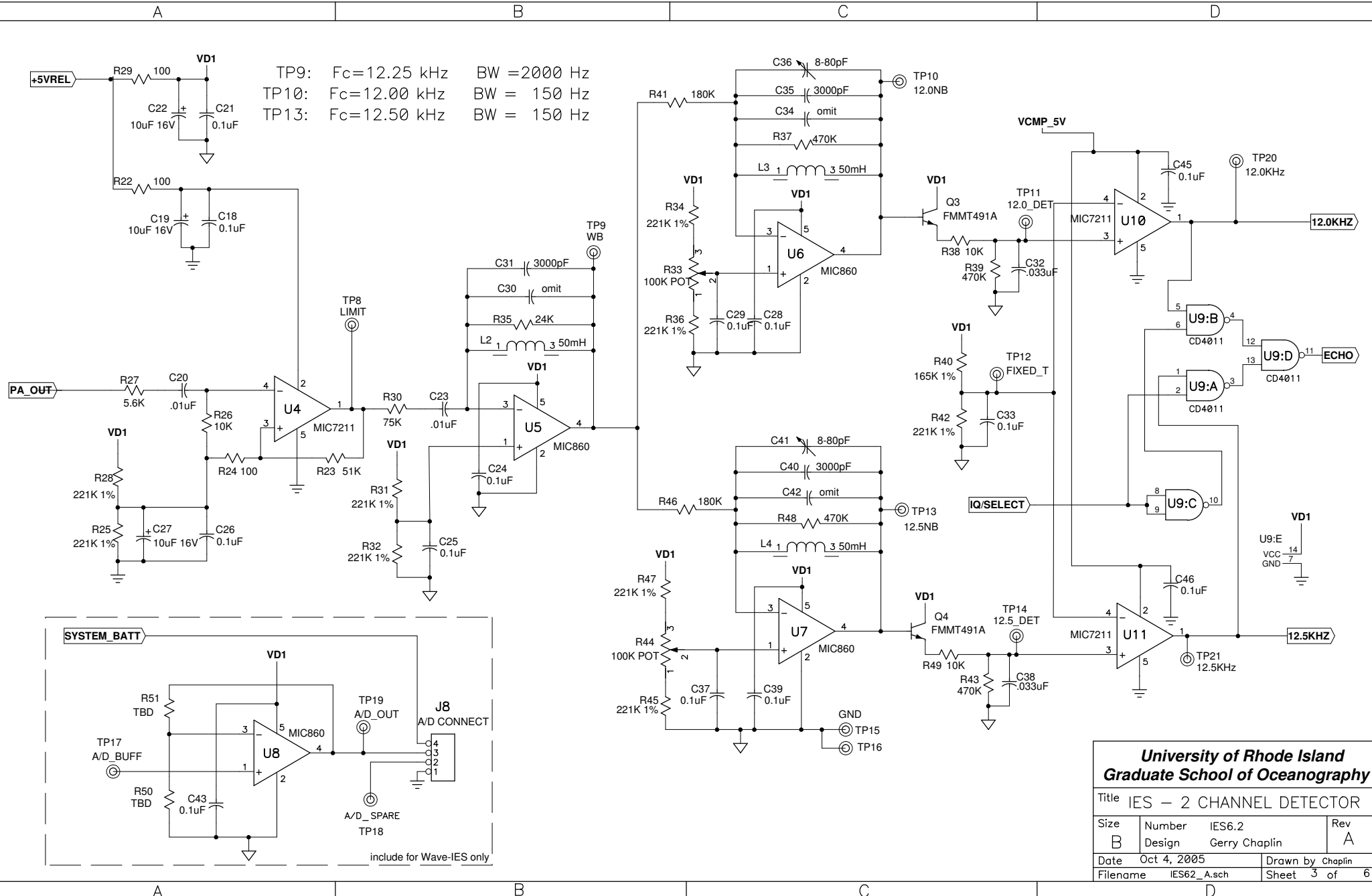
TP9: Fc=12.25 kHz   BW =2000 Hz
TP10: Fc=12.00 kHz   BW = 150 Hz
TP13: Fc=12.50 kHz   BW = 150 Hz

University of Rhode Island
Graduate School of Oceanography

Title IES — 2 CHANNEL DETECTOR

Size	Number	IES6.2	Rev
B	Design	Gerry Chaplin	A

Date	Oct 4, 2005	Drawn by Chaplin
Filename	IES62_A.sch	Sheet 3 of 6

include for Wave-IES only

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RN1 220K SIP

DA3
S16-4148

ACOUSTIC COMMAND
CODE SWITCHES
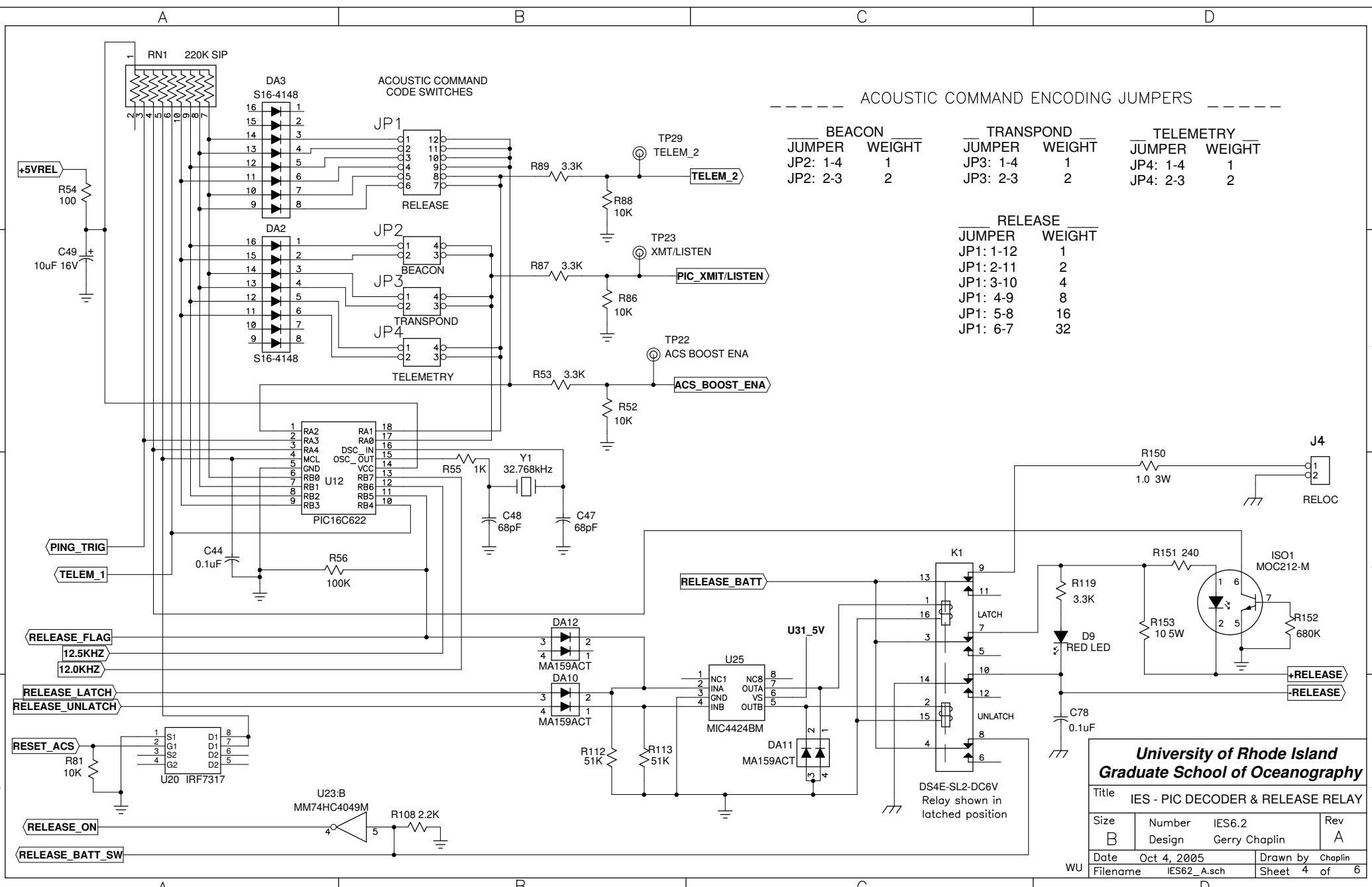
ACOUSTIC COMMAND ENCODING JUMPERS

_____ BEACON _____		
JUMPER	WEIGHT	
JP2: 1-4	1	
JP2: 2-3	2	

__ TRANSPOND __	
JUMPER	WEIGHT
JP3: 1-4	1
JP3: 2-3	2

__ TELEMETRY __	
JUMPER	WEIGHT
JP4: 1-4	1
JP4: 2-3	2

_____ RELEASE _____	
JUMPER	WEIGHT
JP1: 1-12	1
JP1: 2-11	2
JP1: 3-10	4
JP1: 4-9	8
JP1: 5-8	16
JP1: 6-7	32

JP1
RELEASE

+5VREL
R54 100
C49 10uF 16V

DA2

JP2
BEACON

JP3
TRANSPOND

JP4
TELEMETRY

S16-4148

R89 3.3K
TP29 TELEM_2
TELEM_2
R88 10K

R87 3.3K
TP23 XMT/LISTEN
PIC_XMIT/LISTEN
R86 10K

R53 3.3K
TP22 ACS BOOST ENA
ACS_BOOST_ENA
R52 10K

U12 PIC16C622
RA2 RA3 RA4 MCL GND RB0 RB1 RB2 RB3
RA1 RA0 DSC_IN OSC_OUT VCC RB7 RB6 RB5 RB4

R55 1K
Y1 32.768kHz
C48 68pF
C47 68pF

PING_TRIG
TELEM_1
C44 0.1uF
R56 100K

RELEASE_FLAG
12.5KHZ
12.0KHZ
RELEASE_LATCH
RELEASE_UNLATCH

DA12 MA159ACT
DA10 MA159ACT

RESET_ACS
R81 10K
U20 IRF7317
S1 G1 S2 G2
D1 D1 D2 D2

U23:B MM74HC4049M
R108 2.2K
RELEASE_ON
RELEASE_BATT_SW

R112 51K
R113 51K

U25 MIC4424BM
NC1 INA GND INB
NC8 OUTA VS OUTB

U31_5V

DA11 MA159ACT

RELEASE_BATT

K1

LATCH

UNLATCH

DS4E-SL2-DC6V
Relay shown in
latched position

R119 3.3K
D9 RED LED
R151 240
R153 10 5W
ISO1 MOC212-M
R152 680K

R150 1.0 3W
J4
RELOC

C78 0.1uF

+RELEASE
-RELEASE

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University of Rhode Island
Graduate School of Oceanography

Title: IES - REF. OSCILLATOR & DIVIDERS

Size: B

Number: IES6.2
Design: Gerry Chaplin

Rev: A

Date: Feb 23, 2005
Filename: IES62_A.sch

Drawn by: Chaplin
Sheet 5 of 6

WU

A B C D

WATCHDOG TIMER = 12.5 minutes

U27_3V

R128 3.3K
C80 0.1uF
R129 3.3K

U29
1 RESETIN
2 GNDD
4 SRT
3 SWT
VCC 8
WDS 5
(RESET) 7
WD1 6
MAX6301CSA

S3 RESET
R127 1M
C81 .001uF
C79 .56uF

DA13
1 4
2 3
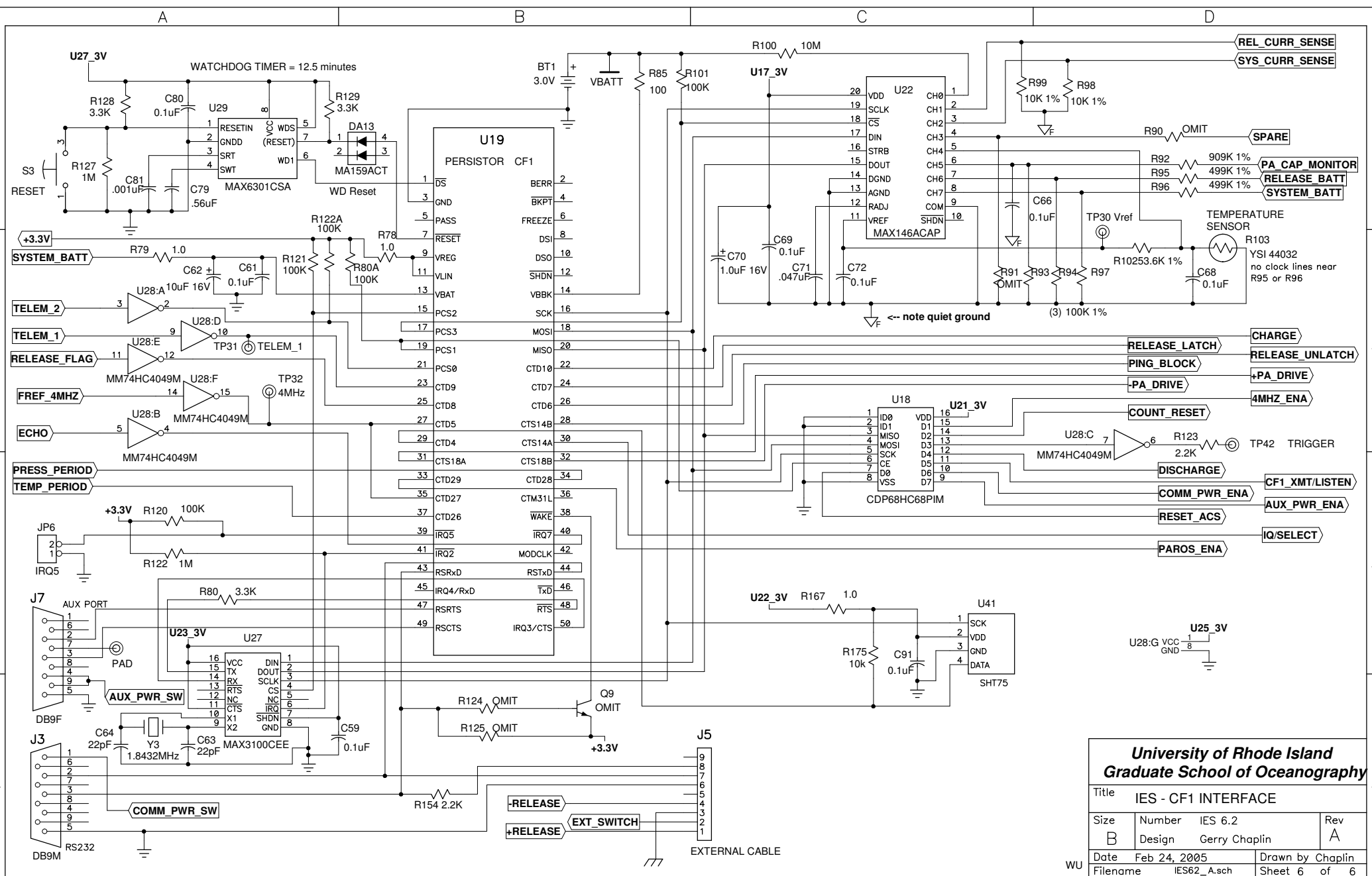MA159ACT
WD Reset

BT1 3.0V +
VBATT
R85 100
R101 100K

R100 10M

U17_3V

U22
20 VDD
19 SCLK
18 CS
17 DIN
16 STRB
15 DOUT
14 DGND
13 AGND
12 RADJ
11 VREF
CH0 1
CH1 2
CH2 3
CH3 4
CH4 5
CH5 6
CH6 7
CH7 8
COM 9
SHDN 10
MAX146ACAP

R99 10K 1%
R98 10K 1%

R90 OMIT
SPARE

R92 909K 1%   PA_CAP_MONITOR
R95 499K 1%   RELEASE_BATT
R96 499K 1%   SYSTEM_BATT

REL_CURR_SENSE
SYS_CURR_SENSE

U19
PERSISTOR CF1
1 DS
3 GND
5 PASS
7 RESET
9 VREG
11 VLIN
13 VBAT
15 PCS2
17 PCS3
19 PCS1
21 PCS0
23 CTD9
25 CTD8
27 CTD5
29 CTD4
31 CTS18A
33 CTD29
35 CTD27
37 CTD26
39 IRQ5
41 IRQ2
43 RSRxD
45 IRQ4/RxD
47 RSRTS
49 RSCTS

BERR 2
BKPT 4
FREEZE 6
DSI 8
DSO 10
SHDN 12
VBBK 14
SCK 16
MOSI 18
MISO 20
CTD10 22
CTD7 24
CTD6 26
CTS14B 28
CTS14A 30
CTS18B 32
CTD28 34
CTM31L 36
WAKE 38
IRQ7 40
MODCLK 42
RSTxD 44
TxD 46
RTS 48
IRQ3/CTS 50

+3.3V
SYSTEM_BATT
R79 1.0
C62 10uF 16V
C61 0.1uF
R122A 100K
R121 100K
R80A 100K
R78 1.0

U28:A
3 2
TELEM_2

U28:D
9 10
TP31 TELEM_1
TELEM_1

U28:E
11 12
RELEASE_FLAG
MM74HC4049M

U28:F
14 15
TP32 4MHz
FREF_4MHZ
MM74HC4049M

U28:B
5 4
ECHO
MM74HC4049M

PRESS_PERIOD
TEMP_PERIOD

+3.3V R120 100K
JP6
2
1
IRQ5
R122 1M

R80 3.3K

J7 AUX PORT
6 1
7 2
8 3
9 4
5
PAD
DB9F
AUX_PWR_SW

U23_3V
U27
16 VCC
15 TX
14 RX
13 RTS
12 NC
11 CTS
10 X1
9 X2
DIN 1
DOUT 2
SCLK 3
CS 4
NC 5
IRQ 6
SHDN 7
GND 8
MAX3100CEE

C64 22pF
Y3 1.8432MHz
C63 22pF
C59 0.1uF

J3
6 1
7 2
8 3
9 4
5
DB9M
RS232
COMM_PWR_SW

C70 1.0uF 16V
C69 0.1uF
C71 .047uF
C72 0.1uF

R91 OMIT
R93
R94
R97
R102 53.6K 1%
(3) 100K 1%

C66 0.1uF
TP30 Vref

TEMPERATURE SENSOR
R103
YSI 44032
no clock lines near R95 or R96
C68 0.1uF

<-- note quiet ground

CHARGE
RELEASE_LATCH   RELEASE_UNLATCH
PING_BLOCK   +PA_DRIVE
-PA_DRIVE
4MHZ_ENA
COUNT_RESET

U18
1 ID0
2 ID1
3 MISO
4 MOSI
5 SCK
6 CE
7 D0
8 VSS
VDD 16
D1 15
D2 14
D3 13
D4 12
D5 11
D6 10
D7 9
CDP68HC68PIM

U21_3V

U28:C
7 6
R123 2.2K
TP42 TRIGGER
MM74HC4049M

DISCHARGE
COMM_PWR_ENA
RESET_ACS
PAROS_ENA

CF1_XMT/LISTEN
AUX_PWR_ENA
IQ/SELECT

U22_3V R167 1.0

R175 10k
C91 0.1uF

U41
1 SCK
2 VDD
3 GND
4 DATA
SHT75

R124 OMIT
R125 OMIT
Q9 OMIT
+3.3V

U25_3V
U28:G VCC 1
GND 8

R154 2.2K

-RELEASE
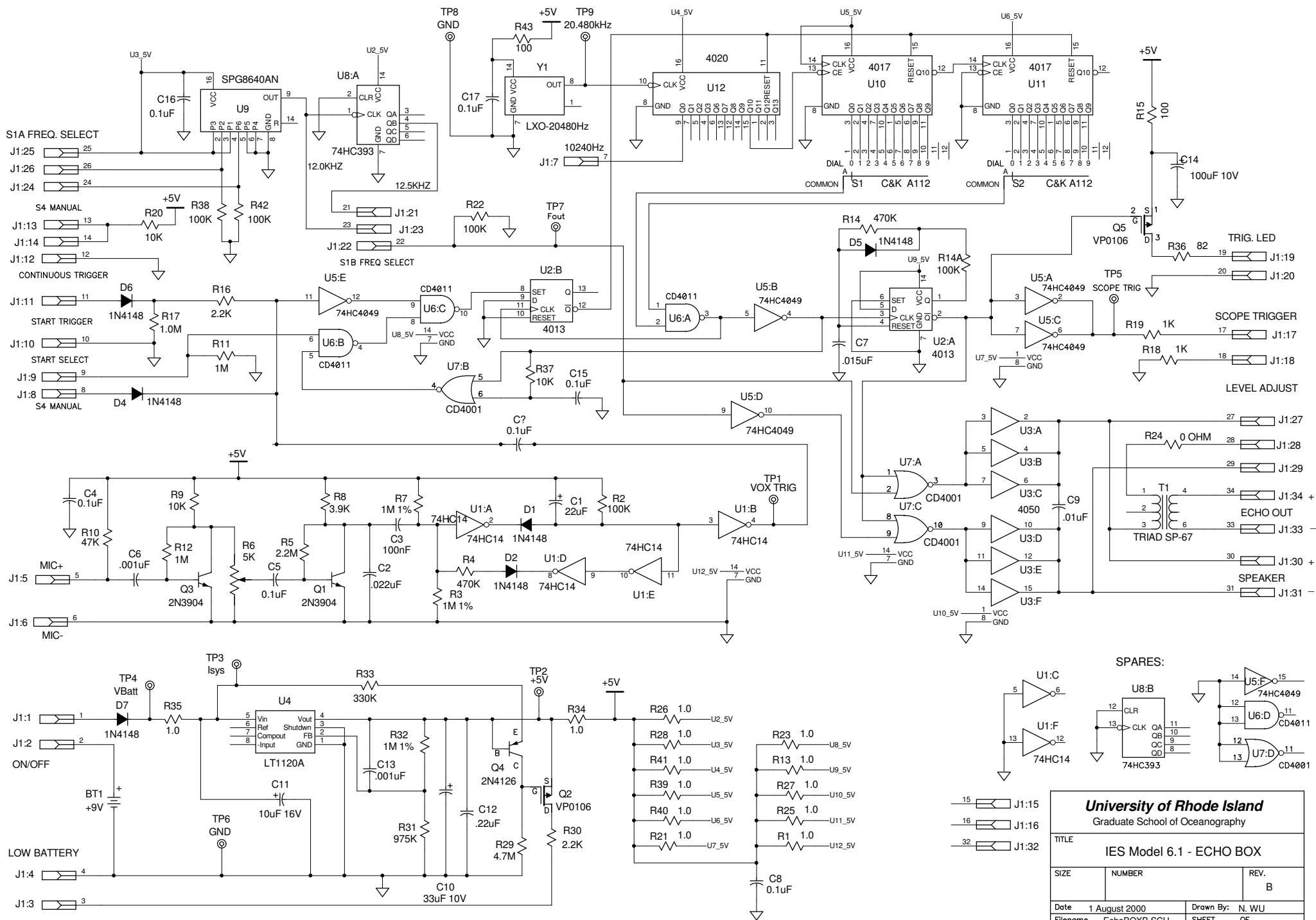+RELEASE   EXT_SWITCH

J5
9
8
7
6
5
4
3
2
1
EXTERNAL CABLE

University of Rhode Island
Graduate School of Oceanography

Title: IES - CF1 INTERFACE

Size B
Number: IES 6.2
Rev A
Design: Gerry Chaplin
Date: Feb 24, 2005
Drawn by: Chaplin
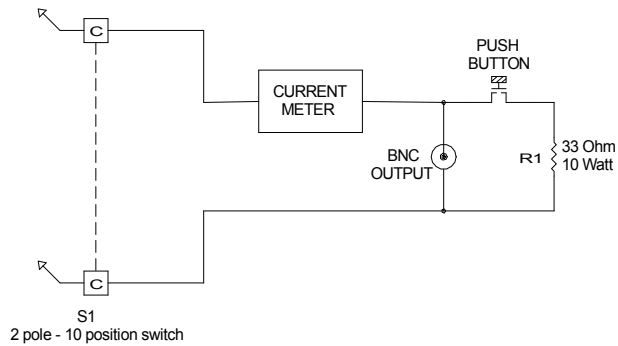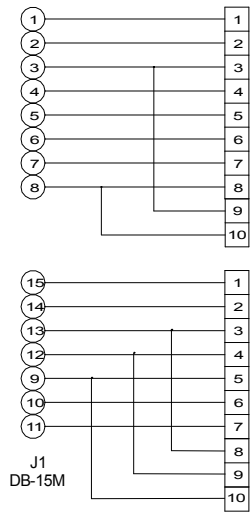Filename: IES62_A.sch
Sheet 6 of 6
WU

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University of Rhode Island
Graduate School of Oceanography

TITLE: IES Model 6.1 - ECHO BOX

SIZE | NUMBER | REV. B

Date: 1 August 2000 | Drawn By: N. WU
Filename: EchoBOXB.SCH | SHEET OF

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URI-GSO BATTERY TESTER

J1

DC milli A

0 100 200 300 400 500

PUSH TO TEST

S1

BNC OUTPUT

Schematic (left side):

J1 DB-15M

S1 — 2 pole - 10 position switch

CURRENT METER

PUSH BUTTON

BNC OUTPUT

R1 — 33 Ohm 10 Watt

SWITCH POSITION	Ampere-Hour Capacity (system/release)					
	120/60		180/60		240/60	
	Vdc	I mA	Vdc	I mA	Vdc	I mA
1	14.5/12.5	350	14.5/12.5	350	14.5/12.5	350
2	14.5/12.5	350	14.5/12.5	350	14.5/12.5	350
3	0.0	0.0	7.4/6.0	200	7.4/6.0	200
4	7.4/6.3	200	7.4/6.3	200	7.4/6.3	200
5	7.4/6.3	200	7.4/6.3	200	7.4/6.3	200
6	7.4/6.3	200	7.4/6.3	200	7.4/6.3	200
7	7.4/6.3	200	7.4/6.3	200	7.4/6.3	200
8	0.0	0.0	7.4/6.0	200	7.4/6.0	200
9	0.0	0.0	0.0	0.0	7.4/6.0	200
10	0.0	0.0	0.0	0.0	7.4/6.0	200
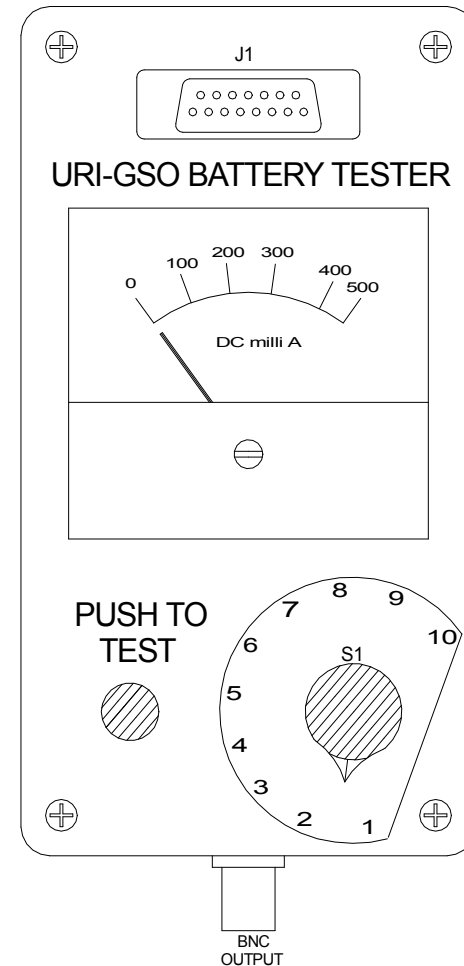
Testing Notes:
1. Connect a DVM to the BNC output and set to Voltage measure.
2. V1/V2: V1 value indicates open circuit Voltage (no push button test).
3. V1/V2: V2 value indicates the minimum value for a new battery when loaded (button pressed).
4. The I ma value indicates the minimum current delivery capacity when loaded (button pressed).
5. If the battery has passivated, press the button intermittently (2 seconds ON, 10 seconds OFF), until the minimum values in the table are reached. DO NOT HOLD THE BUTTON ON.

IES Battery Tester		
URI PN _____	Rev 2	gfc 10.26.05
Scale: none	Sheet 1/1	
URI/GSO Physical Oceanography		

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Appendix B

B.1 Paroscientific Pressure Sensor Specifications

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Appendix C

C.1 Bliley Frequency Reference Crystal Specifications

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Appendix D

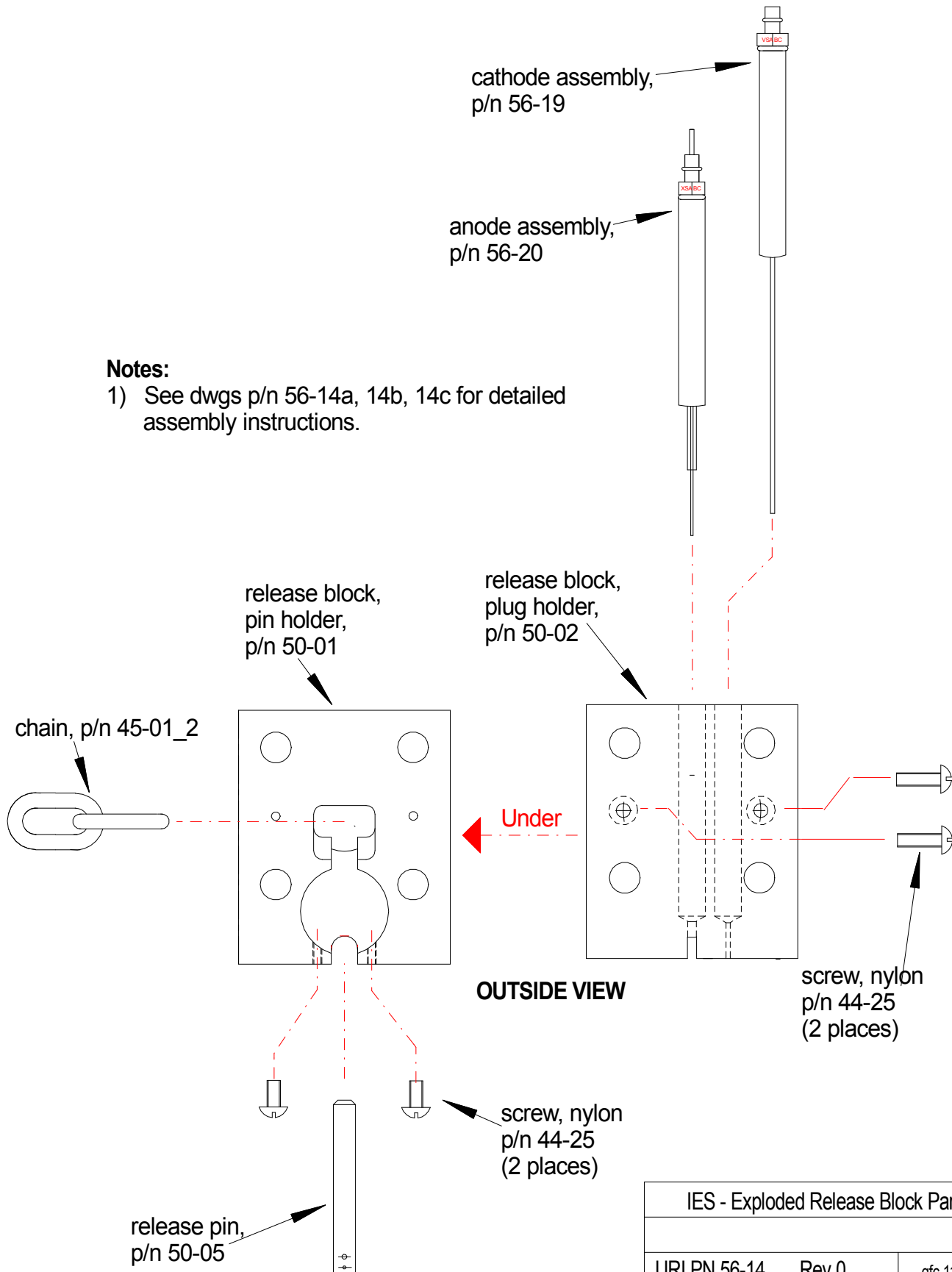**D.1 Release Block Part Numbers**
D.2 Release Block Assembly Instructions
D.3 Mooring Parts:

- IES anchor weight, 50lbs.
  P/N _____
- PIES mooring platform, steel
  P/N 50-27A
- Mooring stand rust guard
  P/N 37-23
- Mooring stand lifting line
  P/N _____

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Appendix D.1   Release Block Parts

cathode assembly,
p/n 56-19

anode assembly,
p/n 56-20

Notes:
1) See dwgs p/n 56-14a, 14b, 14c for detailed assembly instructions.

release block,
pin holder,
p/n 50-01

release block,
plug holder,
p/n 50-02

chain, p/n 45-01_2

Under

screw, nylon
p/n 44-25
(2 places)

OUTSIDE VIEW

screw, nylon
p/n 44-25
(2 places)

release pin,
p/n 50-05

IES - Exploded Release Block Parts		
URI PN 56-14	Rev 0	gfc 11.17.03
Scale: none		Sheet 1 of 4
URI/GSO	Physical Oceanography	

Appendix D.2 Release Block Assembly Instructions

1
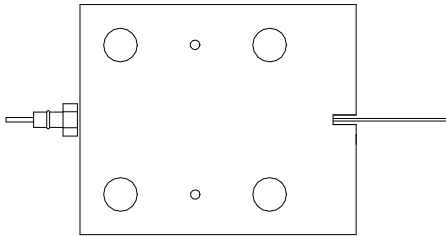
Insert anode (small wire)
into plugholder with connector
fllush with edge, Pull
through with pliers.
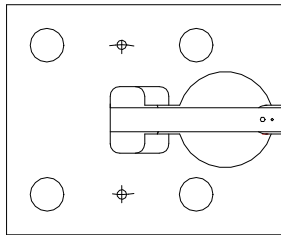Do not hit connector
on hard surface.

2

3/8"
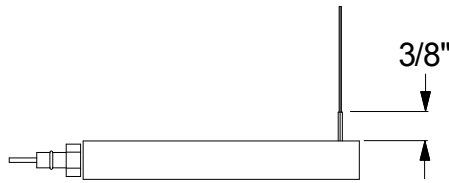
Bend inconel wire up
90 deg. toward release
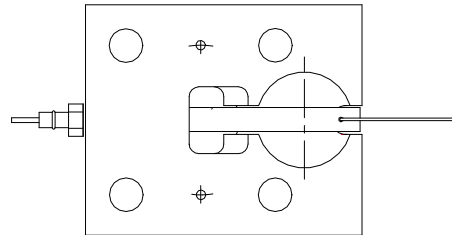block sharply with
heat shrink tubing
exposed 3/8"

3
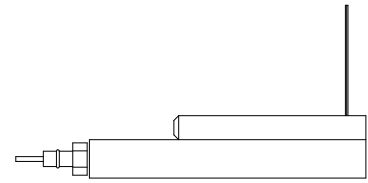
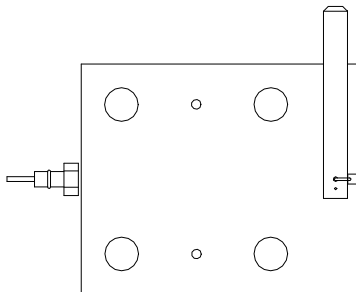Slide fiberglass pin
over wire using
 larger hole

4

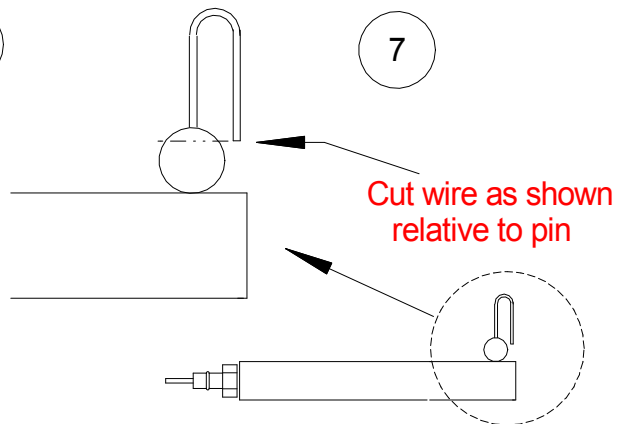Assemble pin holder
onto plug holder with
pin in slot.

5

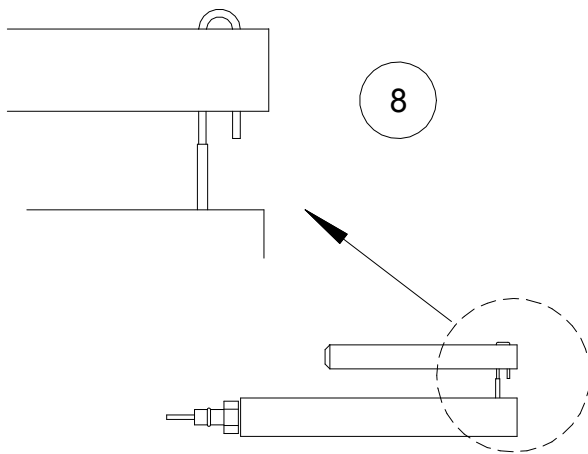Holding pin snug against
pin holder, bend wire
out 90 deg. sharply.

6

Remove pin holder
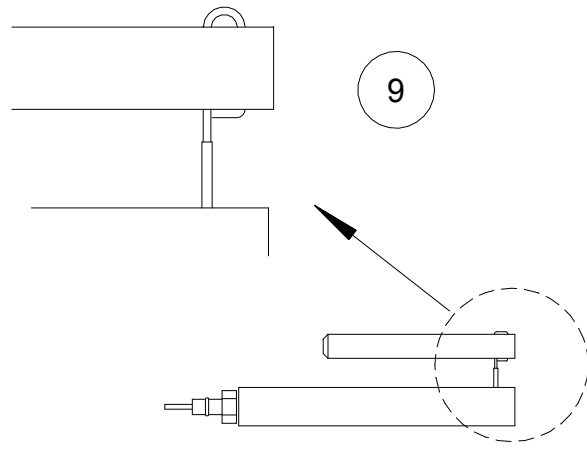and rotate pin 90 deg.
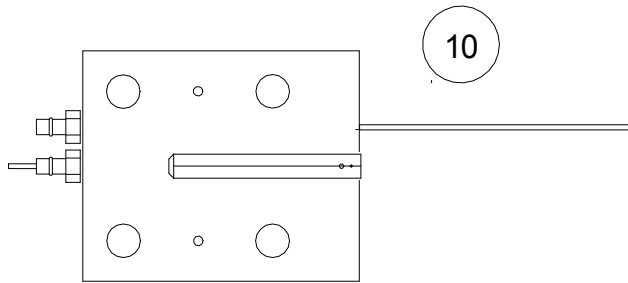Bend wire down sharply
at 90 deg.

7

Cut wire as shown
relative to pin

Bend wire down sharply
at 90 deg. as shown
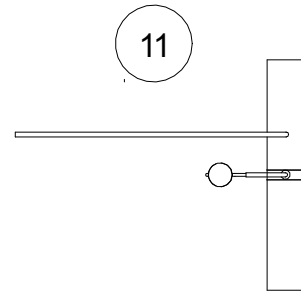
gfc 11.17.03   PN 56-14a

8

Rotate pin back,
feed wire into
secondary hole.

9

Wrap wire around
pin as shown

10

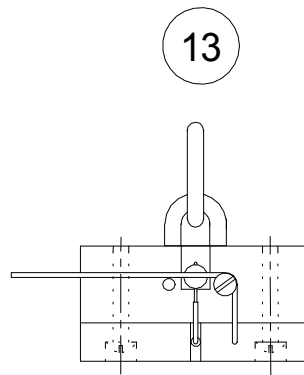Insert cathode (large wire)
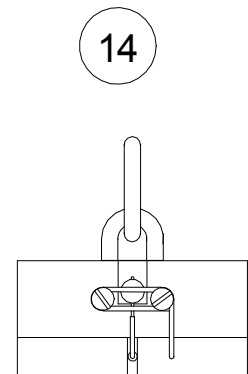into plug holder until
flush with edge.

11

Bend wire up sharply
at 90 deg.
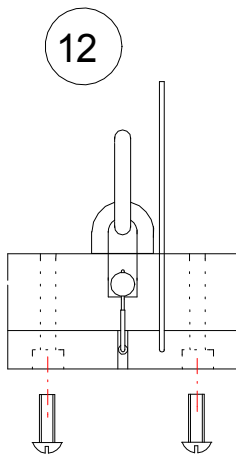
12

Mount pin holder
to plug holder with nylon
#10 - 24 x 1/2 hardware,
including stainless steel
links.

13

Insert screw (nylon) on right
side only. Wrap wire around
screw 90 deg. Insert second screw
on left side. Wrap wire
around screw 180 deg. and trim to
length. Tighten both screws.

14

Cathode - PN 50-01

See note 5

Release pin
PN 50-05

Anode - PN 50-02

Pin Holder
(PN 50-01)

Plug holder
(PN 50-02)
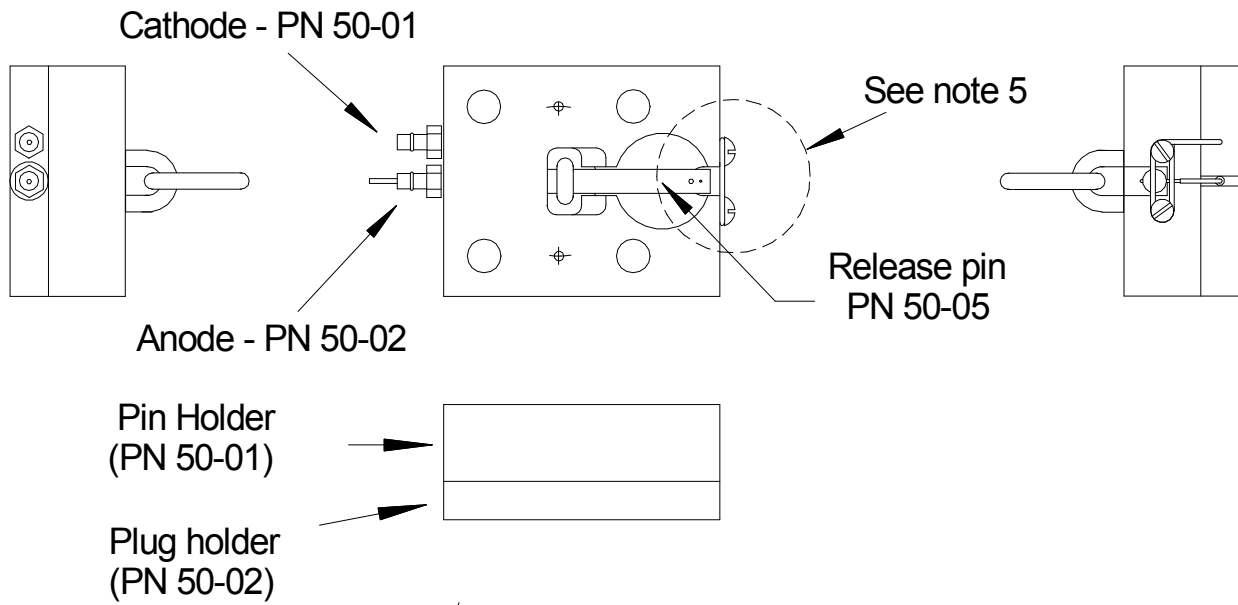
Pre-Deployment Checklist:

1.) Connectors are flush with surface.
2.) Cathode wire clearly obstructs pin movement.
3.) All wiring bends are sharp.
4.) No damage to exposed connectors.
5.) There MUST be 1/8" (+/- 1/32) movement between the
     cathode wire and the release pin. The pin holder
     will compress 1/8' at full deployment depth (10.000 psia),
     potentially jamming the pin, which would prevent
     the instrument from returing to the surface.

Appendix E

E.1 IES Deployment Form
E.2 IES Recovery Form

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Inverted Echo Sounder - Model 6.2
Deployment

IES #_____

Site/Project_____   **Date:**_____

<u>ACS function</u>	<u>Benthos DS-7000 Command</u>
TELEM:	_____
XPND:	_____
BEACON:	_____
RELEASE:	_____
CLEAR:	__76__

TT Measure Rate: _____ pings every _____ minutes
Depth: _____ meters ÷ ____ m/min = sink time =   _____min.

If cPIES: DCS s/n _____   DCS cable s/n_____

Recovery Devices: **Attached & Working?**
         Internal radio/flasher Channel# _____   _____
                              PIES stand   _____
                              Flag   _____

Launch Site: (type of fix _____)

                    _____ °LAT

                    _____ °LONG

IES clock offset from GMT @ launch _____   seconds (+early/- late)

Attach anchor, suspend & check slippage? _____

Time of launch (GMT) _____

            (Local) _____

ACS replies @ _____kHz

Reached bottom @ _____

Bottom TT measure burst @ _____

Burst Telemetry @: _____   DS-7000 GAIN: _____   Distance:_____

SAMPLE#	Tau	Pressure	Speed	Direction
1	_____	_____	_____	_____
2	_____	_____	_____	_____
3	_____	_____	_____	_____
4	_____	_____	_____	_____

ACS CLEAR when leaving site ___
NOTES:

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Inverted Echo Sounder - Model 6.2
Recovery

IES #_____

Site/Project_____   **Date:**_____

ACS function	**Benthos DS-7000 Command**
TELEM:	_____
XPND:	_____
BEACON:	_____
RELEASE:	_____
CLEAR:	__76__

TT Measure Rate: _____ pings every _____ minutes
Depth: _____ meters

Transpond slant range @ release: _____ m

Release command time   _____

Leave bottom time   _____

Surface time   _____

On board time   _____

IES OFF time   _____

IES clock offset from GMT @ recovery _____   seconds (+early/- late)

Radio working?   ____
Flasher working?   ____

NOTES:

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F.1 Refurbishing Kits

- Release re-arming kit,   P/N 10-06
  - anode   P/N 13-06
  - link   P/N 45-01
  - pin   P/N 50-05
  - anchor line   P/N 37-15_93
  - nylon screw   P/N 44-25

- Glass Sphere seal up kit   P/N 10-04
  - 2" wide tape (1 roll, 100ft)   P/N 38-15
  - soft sealing tape (1 roll, 25ft)   P/N 38-16

- Lithium Battery kits (circuit board *and* battery cells for system/release)
  - 120/30 Amp-hour kit (12 cells)   P/N 12-14
  - 120/60 Amp-hour kit (16 cells)   P/N 12-15
  - 180/30 Amp-hour kit (16 cells)   P/N 12-16
  - 180/60 Amp-hour kit (20 cells)   P/N 12-17

- Tool kit   P/N 10-07
  - vacuum port wrench: Allen, 2.5mm   P/N 42-08
  - 9/16' nut driver (2 each)   P/N 42-10
  - 5/16 nut driver   P/N 42-12

- 'O'-ring kit   P/N
  - pressure port   P/N 48-02, Parker P/N 2-015
  - thru-the-glass-cable   P/N 48-04, Parker P/N 2-016
  - vacuum port:
    - glass seal   P/N 48-03   Parker P/N 2-011
    - screw seal   P/N 48-06

- IES Test Accessories Kit   P/N 10-02
  - Echo simulator   P/N 11-14
  - Signal insertion cable   P/N 11-15
  - Release simulator   P/N 11-16

- Spare mechanical parts kit   P/N 10-05
  - nylon hardware: 1.25"x3/8"-16 bolts with washers and nuts (2)
  - nylon hardware: 2.00x3/8"-16" release block mount bolt (1)
  - spare release block – complete assembly (1)
  - anchor line: 5/16" diameter x 93" length Dacron (2)
  - plastic cable ties (6)

The following individual parts and assemblies are available. Contact URI-GSO for pricing… refer to the URI part number.

- Radio/Flasher module with high-band VHF (156.875MHz)   P/N 12-03
- Radio/Flasher module with low-band VHF (43.528MHz)   P/N 12-09
- Radio/Flasher module (with ARGOS receiver)   P/N 12-11
- internal communications cable (standard RS-232 cable, 9-pin female/female) P/N 54-11
- external communications cable (6ft, 10ft, 25ft)   P/Ns 51-05, 06, 07
- battery circuit board assy   P/N 12-13
- external connector plugs:
     ON/OFF   P/N 32-53
     RS232   P/N 32-54
- thru-the-glass cable assembly   P/N 13-12
- pressure port (titanium)   P/N 50-13
- oil resevoir assy (plastic)   P/N 50-19
- vacuum port (titanium)   P/N 50-18
- release block cathode   P/N 13-05
- O-ring grease   P/N 38- 18 or 19   (Dow Corning 4 compound or Parker O Lube Grease)
- pressure system oil   P/N 38-17   (Dow Corning 350-CS)
- lifting belt (bands and grip)   P/N 11-13 (P/Ns 50-22 and 50-20)
- transducer guard   P/N 50-07
- release block guard   P/N 50-06
- flag holder (arm & mounting nut)   P/Ns 50-08 and 50-12
- flag   P/N 52-09
- recovery float   P/N 50-15
- desiccant   P/N 37-06
- Stable mooring platform for deployment with pressure sensor at sites with high bottom current (> 50cm/sec)   P/N 50-27
- Memory cards: (16 – 512Mbyte)
     standard 16MByte   P/N 20-53
- nylon bolts and nuts:
     1”x3/8”-16 bolt   P/N 44-11
     1.25”x3/8”-16 bolt   P/N 44-12
     2”x3/8”-16 bolt   P/N 44-13
     3/8”-16 nut   P/N 44-14
     3/8” washer   P/N 44-15