OPM3792-001
December 1993

3SPACE®

InsideTRAK™

USER'S MANUAL

OPM3792-001
December 1993

NOTICE

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Suggestions:

1. It may be necessary to switch physical board positions within the PC to get the maximum separation from any board(s) which might cause interference to InsideTRAK.

2. Separation between transmitter and receiver cables will enhance operation. Do not bundle these cables together.

For a display of continuous tracking, type C (upper case).

Type c (lower case) to stop the continuous tracking display.

The format of the output record on the screen is:

```
     ----- Board (0, 1 2 or 3)
    |
    |
    | ---- Station (1 or 2 for upper or lower
    ||     Circular DIN connector, respectively)
    ||
    || --- Error code (blank if no error) - see
    |||    Table 3.1 in Appendix A
    |||
    ||| Cartesian coordinates     Euler angles
    |||
    |||    X      Y      Z      AZ     EL     RL
    |||  -------Inches------  ------Degrees------

   01•  12.03  -0.59  -0.12  -1.34   2.76  -0.28
```

The display you see should have numbers similar to those shown in the data line (bottom line) above. You may now move the Receiver and/or the Transmitter and re-orient them and the display will track the movement.

For further information on using the InsideTRAK Interface Program, please refer to Appendix B and the READ.ME file on the diskette.

LIST OF FIGURES

GETTING STARTED

This section defines a quick way to install the InsideTRAK hardware and software for a single receiver and verify the system's operation.

NOTE: InsideTRAK is a new type of tracking instrument in that it resides within your PC and uses certain of your PC's features to perform the tracking function and to output the position and orientation data. As such, both installation and operation of InsideTRAK require you to have some knowledge of your PC -- both mechanical and functional.

NOTE: InsideTRAK employs electromagnetic fields which may be distorted by large metallic objects near the transmitter or receiver. Keep metal desks, file cabinets, etc., at least three times the transmitter to receiver separation distance away from either of these items.

Step 1:

With power to your PC off, remove the cover to gain access to your PC's ISA bus. [**CAUTION:** your PC must be an 80286 ("AT") or higher to have the 16 bit ISA bus; 8088 PCs have only the 8 bit ISA bus; the InsideTRAK board has standard 16 bit ISA dimensions.]

Locate an empty slot. It must be a full length (16 bit) slot. The slot adjacent to the component side of the InsideTRAK should be empty or be a short board so that the taller components at the rear of the InsideTRAK board

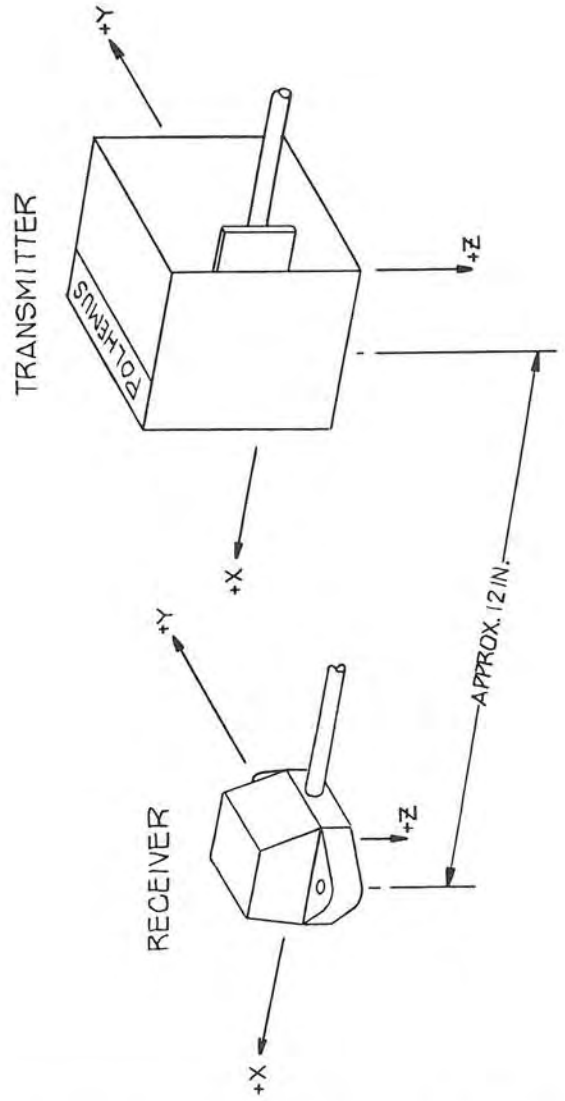


Figure B. InsideTRAK Test Set-Up

Move to this directory:

cd INSIDE

Step 7.

With the floppy disk in Drive A or Drive B, type

a:INSTALLA -or- b:INSTALLB

This batch file copies the files to your new directory.

Now operate from your hard disk and put away the floppy disk.

Step 8.

Invoke the PC resident program supplied by typing

trak

Respond to the question "Monochrome Display? (y,n)" with "y" or "n". After 5 seconds the main menu will reappear.

Step 9.

Position the Transmitter and Receiver on a flat surface, in line and about 12 inches apart as shown in Figure B: InsideTRAK Test Setup.

Step 10.

To display position and orientation on demand, type P (upper case).

do not mechanically or thermally interfere with the adjacent board. If necessary, revise the physical positions of the boards in your PC to accommodate InsideTRAK.

Step 2:

The factory setting on switch S1 (8 position DIP switch located near the ISA Bus connector -- see Figure 2 in the main body of this manual) for the Input/Output (I/O) address is 300 hexadecimal. Allowable settings are 100 hex through 3FC hex. You must ensure that other boards on the ISA bus do not have I/O addresses set for InsideTRAK's address or for any of the next three addresses above its address. See sections 5.4 and 6.0 of this manual for more addressing information.

Step 3.

Ensure that all connectors are firmly seated and that cooling air to InsideTRAK (especially to the power transistors at the rear of the board) is not obstructed. Replace the PC's cover.

Step 4.

Connect the Transmitter Frequency Module to the InsideTRAK faceplate 9 pin D connector. Connect the Transmitter to the Transmitter Frequency Module. Connect the Receiver to the upper circular DIN connector. See Figure A: System Interconnections.

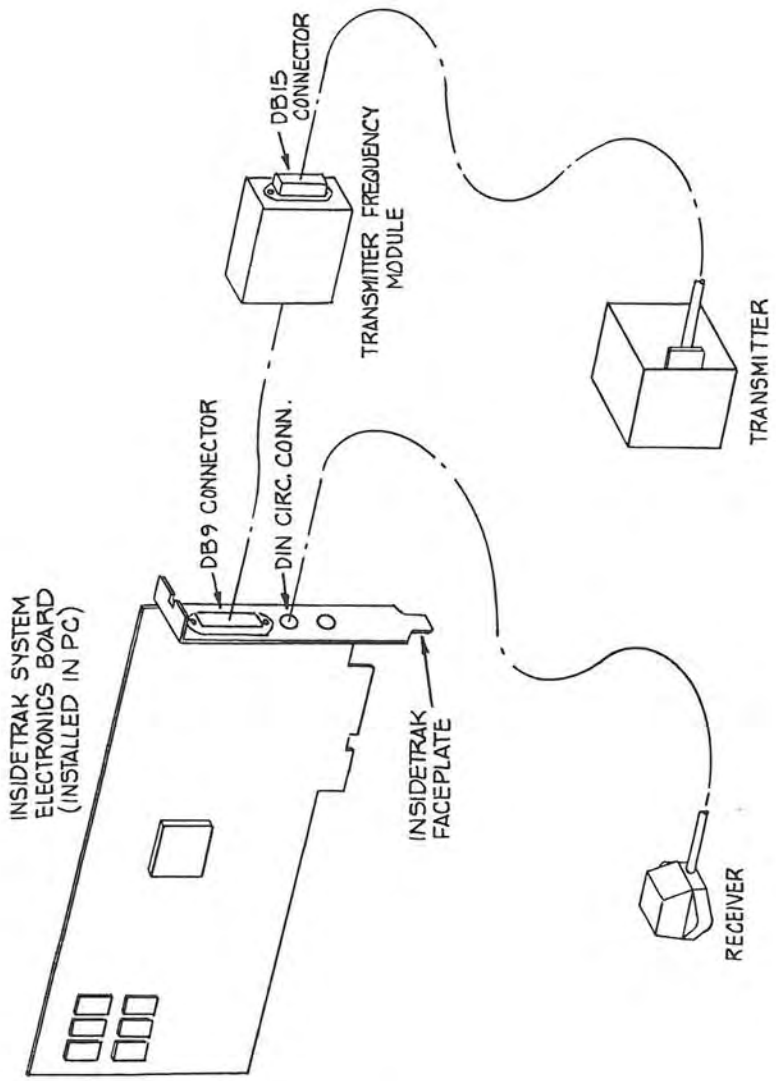


Figure A. System Interconnections

At this point all the hardware has been installed and configured and your PC can be powered up.

In order to use InsideTRAK, the PC must be configured and a program to communicate with the tracking system must be established. The floppy disk ("InsideTRAK Interface Program") supplied with InsideTRAK can be used to assist in this effort.

Step 5.

Include in your CONFIG.SYS file the line

```
device = c:\ANSI.SYS
```

or

```
device = c:\DOS\ANSI.SYS
```

or other inclusion of ANSI.SYS as appropriate for your PC's directory structure.

(Note: the following steps assume you wish to have the program resident on a hard disk. It is, of course, possible to operate from a floppy disk.)

Step 6.

Make a directory for the InsideTRAK files:

```
md INSIDE
```

or any other directory name of your choice.

InsideTRAK™ USER'S MANUAL

1.0 INTRODUCTION

Welcome to the InsideTRAK. We have taken the DSP technology of our electromagnetic, six-degree-of-freedom tracking instrument and made it available for you to put inside your PC. It communicates with your PC's ISA bus and delivers low cost, six-degree-of-freedom tracking information on command. The data in this manual allow you to install and operate your new tracking instrument with speed and efficiency.

2.0 HARDWARE

The InsideTRAK instrument consists of the following standard and optional items:

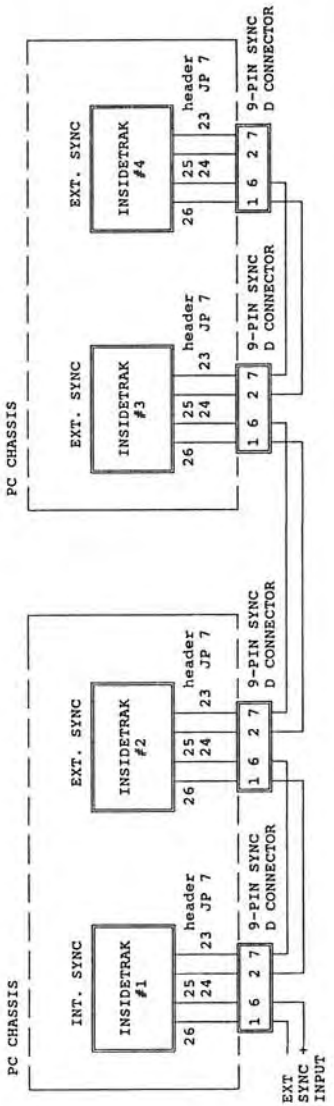
Standard Items

1. Full size PC (AT) compatible, plug-in System Electronics Board (SEB) with attached PC Panel Bracket . . . 4A0327-01
2. Transmitter Frequency Module (TFM) . 3A0417
3. Transmitter with 20' cable . . . 3A0369-06
4. Single Receiver with 20' cable . . . 4A0332
5. InsideTRAK Manual OPM3792-001
6. InsideTRAK Interface Diskette CPG3792-002-01

Optional Items

1. TFM (8 frequencies available) . . . . . 3A0417 by color.
2. Inter-unit Synchronization cable(s) 2A0333-01
3. Additional Receivers with 20' cables 4A0332-01
4. Sync Cable Module (SCM) 2A0333

EXAMPLE 3: Synchronizing two trackers in two chassis.



3.0 OVERVIEW

The InsideTRAK instrument uses electromagnetic fields to determine the position and orientation of a remote object. The technology is based on generating near field, low frequency, magnetic field vectors from a single assembly of three collocated, stationary antennas called a transmitter, and detecting the field vectors with a single assembly of three collocated, remote sensing antennas called a receiver. The sensed signals are input to a mathematical algorithm that computes the receiver's position and orientation relative to the transmitter.

The InsideTRAK instrument consists of a full size, PC (AT) compatible, System Electronics Board (SEB) that plugs into any 16 bit size spare ISA slot within the host PC, a Transmitter Frequency Module (TFM), a single Transmitter and up to two (2) Receivers. The SEB contains the instrument electronics, I/O address select switch (S1), and connectors to support the Transmitter Frequency Module, Transmitter and Receivers. The instrument is capable of operating at any of eight (8) discrete carrier frequencies to allow operation of up to eight instruments in close proximity to one another or to allow selection of a frequency less susceptible to interference from the operating frequencies of nearby equipment.

4.0 SPECIFICATION

Position Coverage **The instrument will provide** the specified accuracy when the receivers are located within a hemisphere with a radius of 30" (76.2 cm.) from the transmitter. Operation with separations of up to 60" (152.4 cm.) is possible with reduced accuracy.

Angular Coverage The receivers are all-attitude.

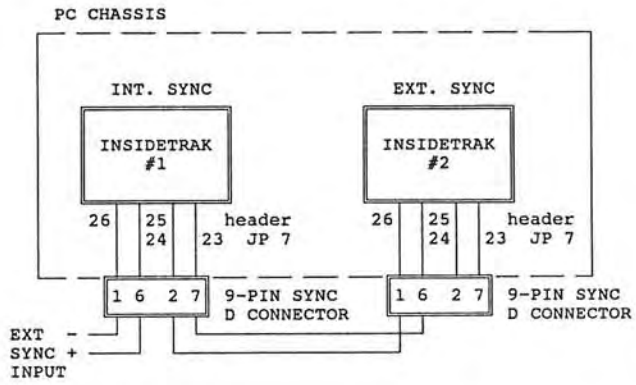
Static Accuracy 0.5" (1.3 cm.) RMS for the X,Y,or Z receiver position, and 2.0° RMS for receiver orientation.

Resolution 0.0003 inches/inch of range (0.0003 cms/cm. of range), and .03°.

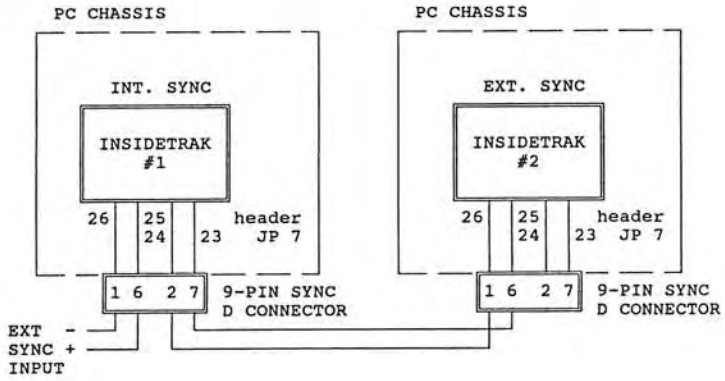
Latency 12.0 milliseconds unfiltered from center of receiver measurement period to beginning of transfer from output port.

Output Software selectable including extended precision. Cartesian coordinates of position and Euler orientation angles are standard. Direction cosines and quaternions are selectable. English or metric units are also selectable.

EXAMPLE 1: Synchronizing two trackers in one chassis.

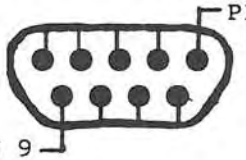


EXAMPLE 2: Synchronizing two trackers in two chassis.



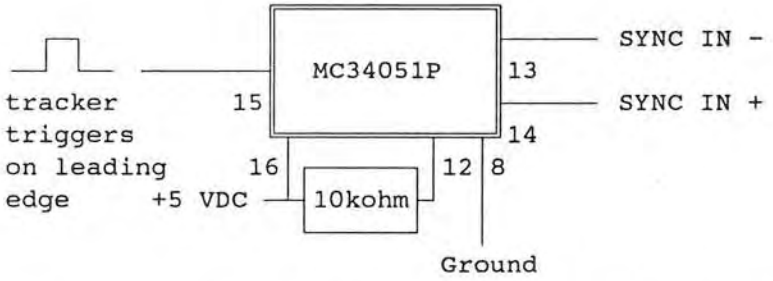
HEADER PIN	JP 7*	SIGNAL
1	26	SYNC IN -
2	24	SYNC OUT -
6	25	SYNC IN +
7	23	SYNC OUT +

PANEL CONNECTOR



* Header pin labeling is on PCB.

Example external sync drive circuit:



Any EIA RS-422 driver may be substituted for this Motorola part.

On the following pages examples of InsideTRAK synchronization arrangements will be given. The 9-Pin Sync D Connector indicated is the Sync Connector Module (Polhemus part number 2A0333) indicated in Section 2.0 of the main manual.

Update Rate

One receiver:	60 updates/second/receiver
Two receivers:	30 updates/second/receiver

Carrier Frequency The InsideTRAK may be configured with any one of eight discrete carrier frequencies to allow simultaneous operation of up to eight instruments in close proximity. Carrier frequencies are selected via color coded Transmitter Frequency Modules (TFM). These frequencies are:

Reference #	Frequency	Color Code
1	8013 Hz (Standard)	Black
2	10016 Hz	Red
3	12019 Hz	Yellow
4	14022 Hz	Blue
5	18027 Hz	Orange
6	20032 Hz	White
7	24039 Hz	Green
8	26042 Hz	Pink

The color dot can be found on the TFM in several locations.

Interfaces ISA Bus. 16 bit wide FIFO for output and 8 bit wide FIFO for input.

Operating Environment Large metallic objects, such as desks or cabinets, located near the transmitter or receivers may adversely affect the performance of the instrument. Other devices employing frequencies near InsideTRAK's

operating frequency should be kept away from the area of operation.

Operating Temperature 10°C to 40°C at a relative humidity of 10% to 95% non-condensing.

Physical Characteristics

SEB: height 4.2" (10.7 cm.) including ISA bus connections, length 13.3" (33.8 cm.), maximum component height 0.625" (1.6 cm.), weight 2.5 lb. (1.13 Kg.).

Transmitter Frequency Module: Width 2.5" (6.4 cm.), length 3.0" (7.6 cm.), height 1.0" (2.54 cm.), weight 3.7 oz. (105.0 gm.) including attached cable. The TFM may be purchased for any of eight (8) distinct carrier frequencies.

Transmitter Width 2.1" (5.3 cm.), length 2.1" (5.3 cm.), height 2.3" (5.8 cm.), weight 0.6 lb. (0.27 Kg.) excluding attached cable.

Receiver Width 1.1" (2.79 cm.), length 0.90" (2.29 cm.), height 0.60" (1.52 cm.), weight 0.6 oz. (17.0 gm.) excluding attached cable.

Power Consumption 15 Watts continuous total from host PC's +5 VDC at 2.2 Amperes max and -5 VDC at 20 milliamperes max.

SYNCHRONIZATION CONNECTION

InsideTRAKs can be either synchronized one to another or can be synchronized to another external process. The pinouts of the 9-pin male D sync connector and the internal header (JP 7) are shown below and some example block diagrams are presented. The trackers can always be hooked up in the way shown, including the external sync input, and then simply set the first InsideTRAK in the chain to external sync or not (internal sync by default). If external sync is not enabled, then the external input is ignored and the remaining chain gets in sync with the first tracker.

IT IS VERY IMPORTANT to use one of these synchronization arrangements along with different frequency modules on each tracker when operating multiple InsideTRAKs in the same environment so that the proper signal rejection of adjacent trackers is accomplished. Please note that it also would be possible to present the same external sync signal to all trackers (or to the lead tracker in each chain of trackers), but one must be careful not to overload the signal source and in general it is safest to take advantage of the sync passalong circuit provided in each InsideTRAK.

The external sync signal is required to be differential, and in order to aid providing such a signal an example circuit compatible with InsideTRAK is given below.

5.0 COMPONENT DESCRIPTION

CAUTION!

Use standard, commercial practice, ELECTROSTATIC DISCHARGE PRECAUTIONS when handling the InsideTRAK SEB. Do not place the SEB on a conductive surface when the SEB has power applied to it.

INSTALLATION

Physical installation of the InsideTRAK SEB into a host PC chassis assumes at least passing knowledge for installing any add-on PCB into a spare slot in a PC chassis.

*** Ensure the SEB ISA connector is firmly and properly seated.**

*** Do not install another full size PCB in the adjacent slot on the component side of the InsideTRAK SEB as the taller components on the rear of the board are power transistor heat sinks that carry both + and - 15 VDC and should not touch other boards.**

*** Ensure there is no blockage of cooling air to the InsideTRAK SEB and that the PC chassis temperature will remain between 10 and 40 degrees Celsius with a relative humidity between 10 and 95% non-condensing.**

If a Sync Cable Module has been ordered, install it in the connector space immediately adjacent to the component side of the SEB. Connect the 26 pin header connector to JP7 with the ribbon cable pointing (hanging) down from the connector (toward the chassis ISA bus connector).

5.1 SEB

The InsideTRAK SEB is a full size, PC (AT) compatible board that plugs into the ISA bus connector. The Receiver Input(s), Transmitter Frequency Module Input (TFM), I/O Address Select Switch (S1), SEB Sync Connector (JP7) and Interrupt Selector Header (JP8) are located on the SEB as shown in Figures 1 and 2.

5.2 Receiver Inputs

The two possible Receiver Input receptacles are 6 pin, female, mini DIN type, designated J2 and J1 and are located on the PCB as shown in Figures 1 and 2. Any one or both Receivers may be plugged in at any time and Receiver selection is via software command. The instrument defaults to one Receiver selected. Specific action is required of the user to turn on Receiver 2.

5.3 Transmitter Frequency Module Output

The single Transmitter Frequency Module Output receptacle is a 9 pin, female "D" type designated P1 and located on the front of the SEB as shown in Figures 1 and 2.

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APPENDIX C

SYNCHRONIZATION CONNECTION

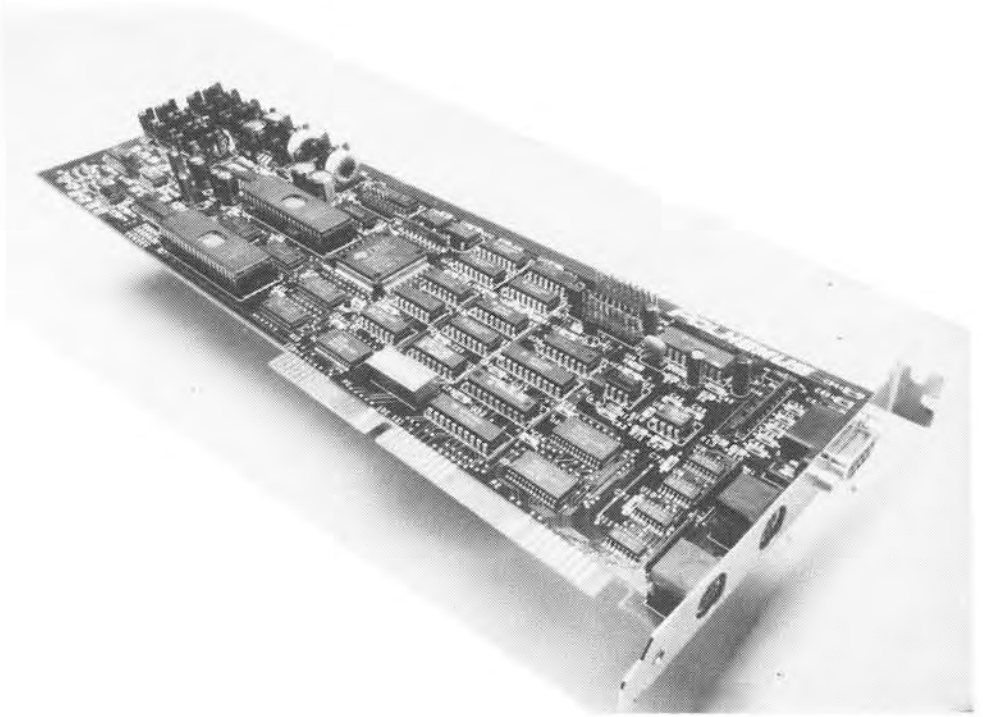


Figure 1. InsideTRAK SEB

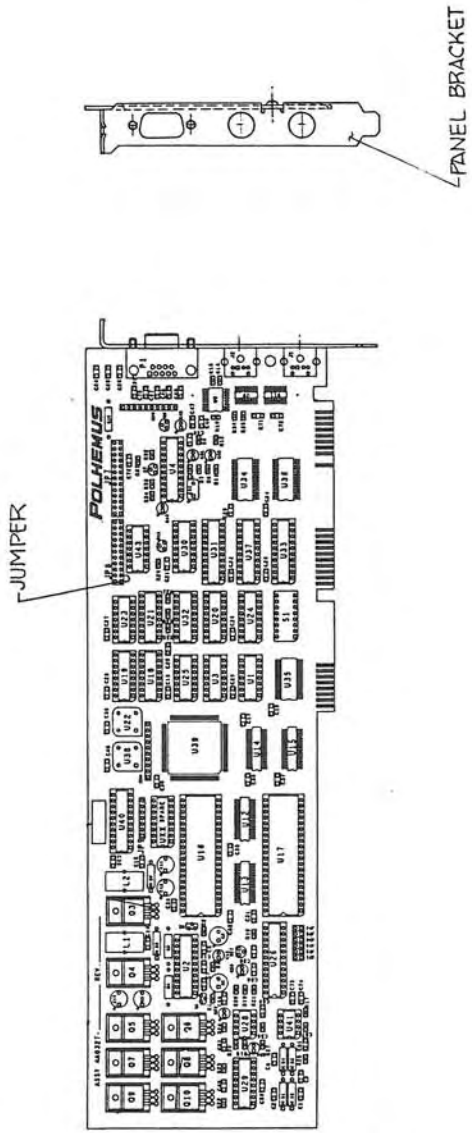


Figure 2. SEB Assembly Drawing

Table 5. ANSI Cursor Positioning And Formatting

Cursor positioning		ESC[PL;PcH
Cursor positioning		ESC[PL;Pcf
Cursor up		ESC[PnA
Cursor down		ESC[PnB
Cursor right(Forward)		ESC[PnC
Cursor left(Backward)		ESC[PnD
Erase display		ESC[2J
Erase line right		ESC[K
Set graphics mode(colors)		ESC[Ps;...Psm
Enter one or more of the following(Ps):		
Text Attributes		All attributes off
0		All attributes off
1		Bold on
4		Underscore(monochrome only)
5		Blink on
7		Reverse Video on.
8		Concealed on.
Colors		
Fore ground	Back ground	Color
30	40	Black
31	41	RED
32	42	Green
33	43	Yellow
34	44	Blue
35	45	Magenta
36	46	Cyan
37	47	White

Other escape sequences are not used.

13.2 DOS Configuration

The interface program uses ANSI escape sequences to format the screen and to position the cursor. As a result, you must include in your CONFIG.SYS file the line:

device=C:\DOS\ANSI.SYS or some other location of ANSI.SYS applicable to your directory structure

13.3 MS-DOS ANSI Escape Sequences Screen Format And Control

The program uses a set of ANSI standard escape sequences for screen formatting and control. No attempt is made to query for the monitor on the system, either of the operator or by hardware registers. Better resource utilization can be achieved by this enhancement. A color CGA/ VGA/ or EGA monitor is assumed as minimum configuration. These ANSI escape sequences are used by the ANSI.SYS screen driver. A full description of these can be found in the appropriate ANSI standard as well as in a Microsoft® MS-DOS User's Guide and Reference manual. Refer to the chapter on customizing your MS-DOS system as well as the Appendix on the ANSI device driver.

A list of the codes used are shown in Table 5.

5.4 Board (I/O) Address Select Switch (1)

In the I/O, all data transfers are single byte or word (2 byte) transfers in the host PC's I/O space of 1024 (2^{10}) addresses. The SEB transfers data to 4 consecutive addresses starting at the address determined by the 8 position switch located on the lower edge of the SEB (near the ISA connector). See Figures 1 and 2. The switch positions and their address weightings are:

Position	Address Bit	Starting Hex Address Contribution if Position = 1 (Down)
Internal to SEB	2^0	0
Internal to SEB	2^1	0
1	2^2	4
2	2^3	8
3	2^4	10
4	2^5	20
5	2^6	40
6	2^7	80
7	2^8	100
8	2^9	200

Note: **UP** (ON) is a logic "0"; **DOWN** (OFF)is a logic "1".

Be sure to use the same address established on the switch in your program.

Example:

If Positions 1, 2, 6, and 7 are UP while Positions 3, 4, 5, and 8 are DOWN, Hex address 270 is the first of the four consecutive addresses for data transfer. Hex 300 is the

factory setting (positions 7 and 8 OFF, all others ON).

5.5 SEB Sync Connector

The SEB Sync Connector is located on the upper front edge of the SEB as shown in Figures 1 and 2 and is designated as JP7. The connector is a 26 pin header used to connect the Sync function. Sync connections to the SEB are via an optionally supplied ribbon cable assembly. The Sync function outputs a pulse in synchronization with the tracking function and/or allows another device to synchronize the tracking function to an input pulse.

See Appendix C for more information on synchronization.

5.6 Interrupt Selector Header

The Interrupt Selector Header (ISH) is located on the upper front edge, immediately below the SEB Sync Connector and designated as JP8. The ISH is a 22 pin header with a movable 2 pin jumper. The ISH jumper (see Figure 2) selects which interrupt request is to be generated to the PC when the SEB has an output record ready in its FIFO. The ISH jumper position and corresponding interrupt request is as follows:

Jumper Pos.	Interrupt Request
1 - 3	none
1 - 2	3
3 - 4	4

the software. The least significant two bits have the following functionality:

Table 2.
I/O Board Control Bit Definition[CT 1,0]

Bit 0	Bit 1	Input/Output Functionality	Direction
0	1	8 bit Data transfer Transmit	PC to IT
0	0	16 bit data transfer Receive	IT to PC
1	0	Request for Immediate data stn A	PC to IT
0	1	Request for immediate data stn B	PC to IT
1	1	Send software synchronization pulse	PC to IT

Table 3. I/O Board Address Mapping

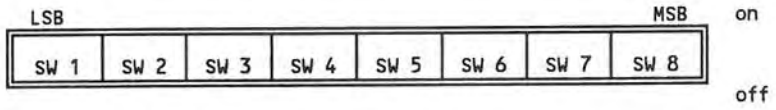
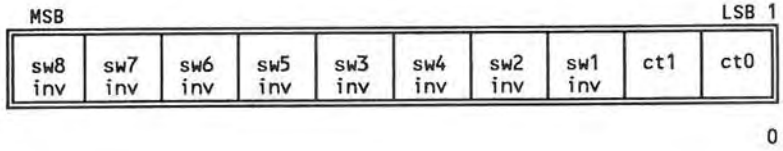


Table 4. PC Board Address



Only the master InsideTRAK board has this sync. Thus the sync command should not be sent to slave boards. This signal is sent to the board with index 0, always presumed to be the master of self and of the slaves.

The InsideTRAK requires a special procedure to exit software sync mode. This requires sending a sync mode change command (yn) to set the sync mode to some other mode: internal/none(0) or external(1). This command is to be followed by the previously existing software sync signal. For reference use the following chart:

Port signal actions	InsideTRAK command sequences
Send command to turn s/w sync off y0<>	type F1 for data capture type y1<>
Send a software sync command: send any data to base port +	3Send a software sync command type F3
Test the effectiveness by requesting data from the port One of transmit 'P' to the base port, request status or static data.	Test the effectiveness by requesting data from the port One of transmit 'P' to the base port, request status or static data.

13.0 Configuring The PC

13.1 Board Address Conversion

A set of DIP switches on the PC/InsideTRAK boards define the address of the input and output relative to the PC. The values of the DIP switches are inverted by the hardware in forming the addresses. No additional inversion is done by

5 - 6	5
7 - 8	6
9 - 10	7
11 - 12	9
13 - 14	10
15 - 16	11
17 - 18	12
19 - 20	14
21 - 22	15

See paragraph 6.1 of this manual for a further discussion of interrupt I/O.

5.7 Sync Cable Module (Optional)

The Sync Cable Module (SCM) comprises a 9 pin, male "D" connector mounted on a PC Panel Bracket with a 9 wire, 6 inch long ribbon cable connected to a 26 pin header connector. The pinouts for the 9 pin "D" connector are as follows:

Pin #	Function
6	SYNC IN POSITIVE (RS-422 "A'" circuit)
1	SYNC IN NEGATIVE (RS-422 "B'" circuit)
7	SYNC OUT POSITIVE (RS-422 "A" circuit)
2	SYNC OUT NEGATIVE (RS-422 "B" circuit)
3	SYSTEM GROUND

See paragraph 7.0 for synchronization signal definitions and Appendix C for synchronization samples.

5.8 Transmitter Frequency Module

The Transmitter Frequency Module (TFM) is a separate unit that provides the unique carrier frequency for the InsideTRAK instrument. The eight available frequencies with their corresponding color code are listed in section 4.0 under "Carrier Frequency." The TFM plugs directly into the P1 port on the SEB via a 9 pin male "D" connector located at the end of a one foot attached cable. The opposite side of the TFM package has a 15 pin "D" connector that accepts the Transmitter connecter. Note: it is acceptable to plug a FASTRAK transmitter into this port without harming either the InsideTRAK instrument or the FASTRAK Transmitter itself. **CAUTION! DO NOT CHANGE TFM MODULES WITH POWER ON!** The TFM is shown in Figure 3.

5.9 Transmitter

The transmitter is dimensionally shown in Figure 4 including the position of the electrical center. There are four, 1/4" - 20 NC tapped holes provided on the bottom surface for mounting. Nylon hardware (supplied) should be used when locating the Transmitter in a fixed position.

5.10 Receiver(s)

The Receiver is dimensionally shown in Figure 5 including the position of the electrical center. The Receiver package provides two mounting holes for #4 screws

11.0 Configuration Of The InsideTRAK Board And PC Program

This option provides total configuring of the InsideTRAK and interface programs. All commands, and interface board addresses are loaded by this function. Copies of the structures and arrays are saved in the PC interface memory for update and subsequent save. Indices of the slave boards are defined by the sequence of the port addresses in this file. The master board index is always zero. Use board management commands F4 for list of the indices and board addresses currently configured.

A port configuration record precedes the InsideTRAK data configurations of each board. It is possible to override the on/off status previously configured manually or automatically with this option.

The format of the record is :

PORT [hex-port_address] [on-off-configure-state]

The port address is input in hexadecimal and should be a legitimate value for the board. The on-off state is optional, and if absent will leave the state of the board unchanged. If present, a 0 turns the board state off, otherwise on.

12.0 System Software Sync

It is presumed that the system has been configured for sync when this command is given.

- Absence of data in the FIFO or more than an expected amount of data defines the card (port) as off.

Some logic exists in initial configuration or in the F4,2 command not to configure some cases of boards with identical board addresses.

9.0 Sensor Numbering Algorithm

If using/modifying the supplied source code, keep in mind that the first index [0] of the configured InsideTRAK boards is assumed to be the master board. The operator will insure that this is the case. The first sensor on any given board will have the lower sensor/station number. Internally these numbers differ from output and input by 1. In the command data display these will be 1 or 2.

Interface data structures number the stations 0 to 7. Bits 2 and 3 of the index (station number - 1) indicate the index of the board(up to 4). Index for data structures = [sensor number - 1]+[board index * 2]

10.0 Data Saved For Configuration

The saved configuration data file contains records defining the port for each subsequent data record. Subsequent port definition records re-increment the index and modify the port address. Skips of ports is possible by including records that simply change the port address. The port identifier begins in the start position of a record and is the word "*PORT*" followed by the port address in hexadecimal.

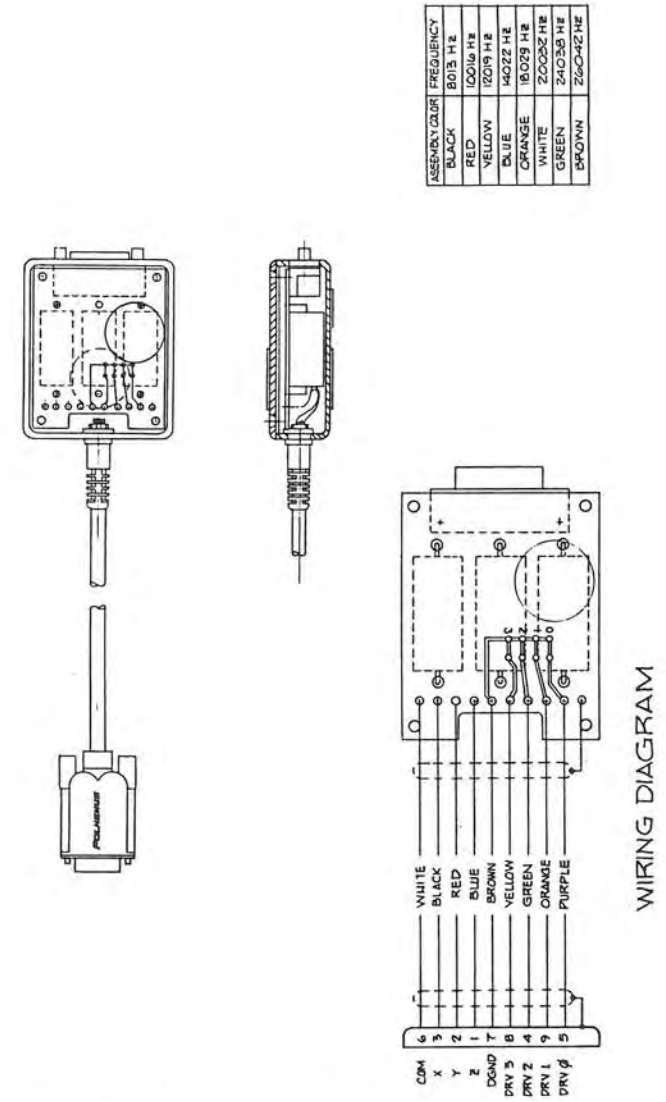


Figure 3. Transmitter Frequency Module (TFM)

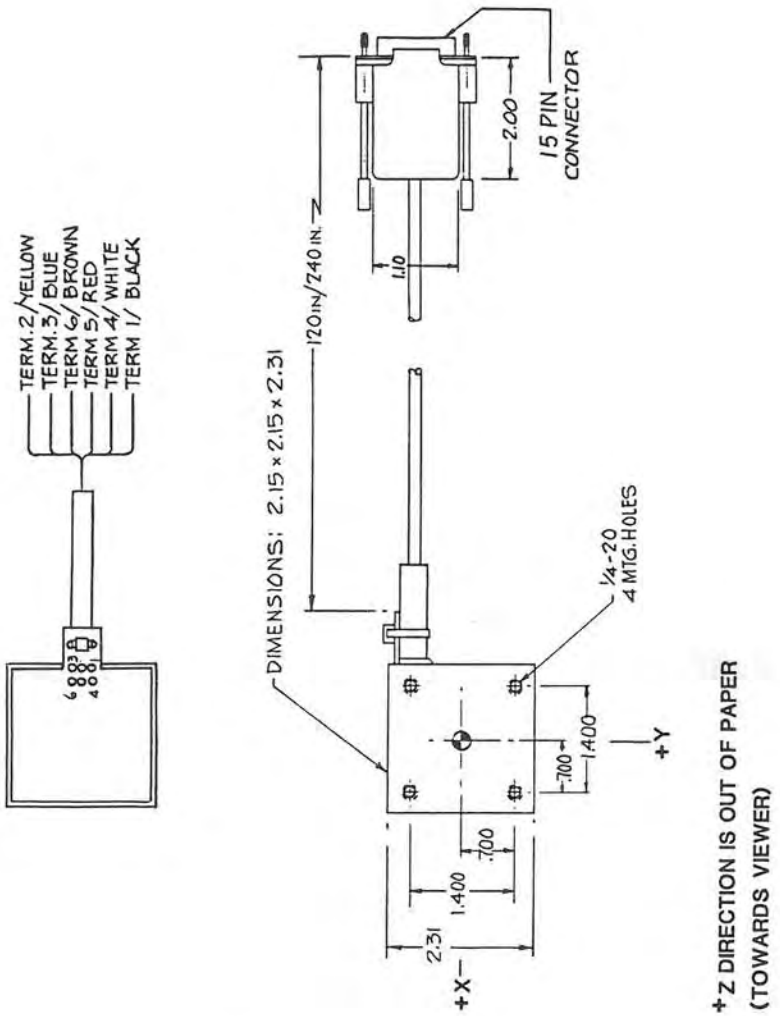


Figure 4. Transmitter

from the configuration file override the PC interface defaults by being written to the save configuration file. Caution should be exercised, as the PC interface defaults may not conform to those of the InsideTRAK. A quick deletion of such divergent commands from the save file should be done before reuse as a new configuration file.

7.0 Port Setup.

Station indices in the interface program are in key-in sequence of the interface program. The port sequence is essential to specify correct configuration data. The InsideTRAK embedded software always enables a SINGLE station (receiver). The second station, if present, must be explicitly enabled by the use of the "l" (lower case el) command.

8.0 Determination Of Active Processor Boards

The software will determine if the InsideTRAK cards are active by flushing the incoming FIFO. The expected sequence is as follows:

- Assume non-continuous operation (a c command has been issued).
- Read up to 511 words of data to flush the incoming FIFO.
- Issue an S command to the outgoing FIFO.
- Wait 50 milli-seconds.
- Test for data on the incoming FIFO.
- Presence of an expected amount of data (S record) is evidence of the card (port) being active.

6.1 File

This provides the means of saving alternate configuration files. A filename is requested on both input as well as output.

6.2 Input

The input configuration file may be selected and accessed on each power on. Data from such access is copied and saved in the interface program as well as downloaded to the InsideTRAK. Port address information as well as embedded systems information may be entered here.

The recipient board is determined by the *PORT* record. Active port is reset to index 0 at the end of this sequence.

A separate configuration file is provided on the floppy disk for each of the eight Transmitter Frequency Modules (TFM):

CONFIG.F1 is for 8 kHz TFM
CONFIG.F2 is for 10 kHz TFM
CONFIG.F3 is for 12 kHz TFM
CONFIG.F4 is for 14 kHz TFM
CONFIG.F5 is for 18 kHz TFM
CONFIG.F6 is for 20 kHz TFM
CONFIG.F7 is for 24 kHz TFM
CONFIG.F8 is for 26 kHz TFM

6.3 Output

The output configuration file can be saved to a data file. The save filename is requested for this command. Operator and input commands

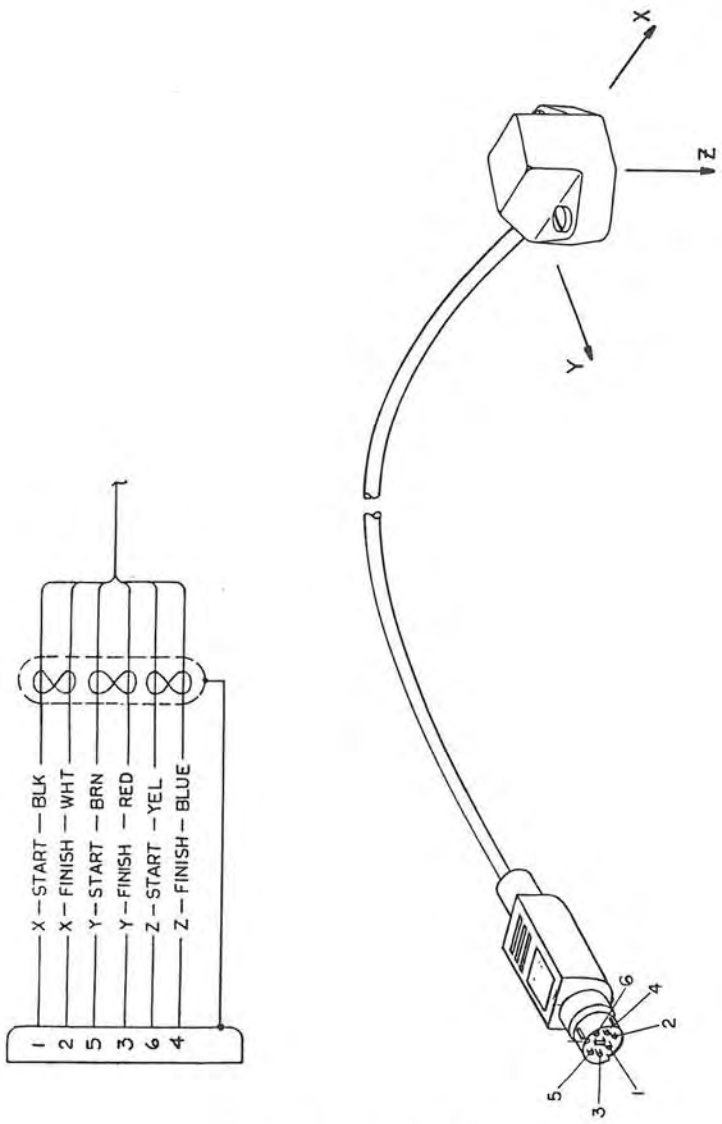


Figure 5. Receiver

(supplied) in the event that Receiver mounting is required. In this case, the supplied nylon hardware is required.

5.11 Diskette

There is one diskette that accompanies this instrument called the InsideTRAK Interface Program.

The Interface Program allows PC host/instrument communication, testing and data collection without detailed knowledge of the PC interface.

Refer to the READ.ME file on the diskette for contents of the diskette.

Output format definition. Format codes 8-10, 12-15, 52 and above are IEEE floating point, 0 and 50 generate a single space, 1 and 51 generate the CR-LF characters, and 3 and 53 are illegal and may cause program disruption.

5.5 Metric Selection

The metric flag is used in the ASCII output that passes through the interface program for structure and static data. The sole use of this flag in the interface program is to modify the scale constant for formats 52 and 2. Metric / US units are already assigned in the ASCII static data records by the InsideTRAK system.

When the file configuration is properly used, that is, the F1 key is used to change all configured boards consistently, then the metric[cm]/US[inches] linear units will be consistent between the interface program and the InsideTRAK.

6.0 Configuration Data

The InsideTRAK maintains the configuration data on file, and in memory. The program must specify the name of the input file to access data. After modifying the data, a data save command may be issued. The configuration of the port addresses and captured data is processed by configuration load and save of the interface program.

5.1 Static Data

Static data is output in ASCII mode, and is passed to the PC display medium. Due to additional difficulties in parsing poorly delimited fields, no attempt is made to parse and capture static data from the InsideTRAK bus interface. Screen and file capture alone are used.

5.2 InsideTRAK

Each InsideTRAK outputs to a FIFO queue, for output by the interface program. Only those boards configured will be accessed by the interface program.

5.3 Formatting

A structure in the interface program will identify formatting routines, the count of items to print per format item, size of item, and scaling numbers. Only format types 0, 1, 2, 4-15, and 50,51,52,54-65 are legitimate. The user must specify the format of output consistently to the InsideTRAK and the interface program. Ideally a configuration file is used for this purpose.

5.4 Binary Format Selection

Two format selections are available for binary data. A low resolution binary 16 bit form and an IEEE floating point binary form. A copy of the word length and conversion codes are maintained in the interface program, The formatting codes for each station are captured using function key F1 when trapping the "O"

6.0 CONFIGURATION

Discussion

The ISA Bus interface is a 16 bit wide FIFO for output and an 8 bit wide FIFO for input. There are input bits to monitor the status of the FIFOs (empty or full). An interrupt request may be generated to the PC for output data transfers. The SEB I/O address is selected by S1 (I/O Address Select Switch) and the SEB only occupies four (4) address locations. One of eleven (11) Interrupt Requests may be selected by a jumper on the SEB. Please see Sections 5.4 and 5.6.

PC I/O Address Map Summary

For convenience, a summary of a host PC Address Map is presented as follows:

Address Range (HEX)	DEVICE
000-0FF	All used by internal I/O
200-20F	Game I/O adapter
278-27F	Reserved
2F8-2FF	Reserved
320-32F	Hard Disk Drive (PC XT only)
378-37F	Parallel Printer Port
3B0-3BF	IBM monochrome CRT & parallel printer
3F0-3F7	5 1/4in. Disk Drive Adapter
3F8-3FF	Asynchronous Communications Adapter

These cover the standard I/O options, but if you have other I/O peripherals such as hard disk drives, special graphics boards, prototypes etc. they will also be sharing I/O address space. Memory addressing is separate from I/O addressing so there is no possible conflict with any add-on memory.

Usually, good choices for the InsideTRAK instrument are Hex 300, 304 or 308. If you are using an IBM prototype board, it uses the HEX 300-31F address space and would conflict. HEX 330 or 340 would then be a good choice if this is the case.

6.1 I/O Data and Interrupts

Output Data: data are output from the InsideTRAK instrument using 16 bit word transfers at Address Offset 0 from the base address selected by the I/O Address Select Switch (S1).

The output FIFO is updated only after data has been removed from it. This means that the FIFO can contain only one output record at a time. In order to check for FIFO output data availability, a byte input from Address Offset 1 is performed. Bit 0 is the status of the FIFO and a **logical "0"** indicates that the FIFO is **empty.**

There is a Special Output Mode (SOM) that reports when the most recent data is available from either receiver. The SOM is evoked by a

4.1.8 Print Immediately (F5)

This is an exerciser to the immediate flush and print buffer option in the InsideTRAK. The "P" and "C" commands operate more directly in the interactive mode.

4.1.9 Program Termination (F10)

This key-in terminates the program and returns to DOS.

4.2 Data Output Menus

Four lines of data per board or two per station are allocated to the formatting of the two stations allocated per board. Data is variable depending on the output selection for the board and station. A subroutine processes a set of program options for the keyboard.

See Appendix A, Chapters 1 and 2, "O" Command section for output options.

5.0 Data Types Available

InsideTRAK outputs three data forms; Static structure data, 16 bit scaled binary integer algorithm data, as well as IEEE floating point binary algorithm data. Each binary form requires output formatting. There is no binary mode file output in the current implementation of the interface program.

Figure 11. Define Command Handler Active Board

```
Board management options select 1-8
1. Program Identification.     5. Toggle selected board activity
2. Ident and board active      6. Define Command Handler Active Board
3. Add next board              7. Modify display colors
Enter the index(0-3) of the active board for command handler ->
->
```

The display will change to Figure 2 with the new command active state indicated.

4.1.7.7 Modify Display Colors (7)

This option returns the program to the initial display setup questions.

4.1.7.8 Toggle Extended [Diagnostic] Display Mode (8)

This toggles and momentarily displays the display state of the system. Additional internal logic paths are altered by this state. This option is intended for factory use only. No additional documentation will be made available except through special request to the factory.

dummy byte output to the appropriate address as follows:

Rcvr 1	Address Offset 1
Rcvr 2	Address Offset 2

Input Data: data are input to the InsideTRAK instrument by using Address Offset 0. The FIFO full flag should be checked before sending commands to the instrument. A byte input from Address Offset 1 is performed. Bit 1 is the status of the FIFO and a **logical "0"** indicates that the FIFO is full. The FIFO is capable of holding 512 bytes.

Interrupts: When the InsideTRAK instrument has an output record available in the FIFO, an interrupt may be generated to the host PC. Which interrupt request is to be generated, if any, is selected by the jumper on the ISH (JP8) on the SEB. (Please refer to section 5.6 for the jumper position/interrupt request table.) The interrupt is cleared by the first input from the instrument's output FIFO.

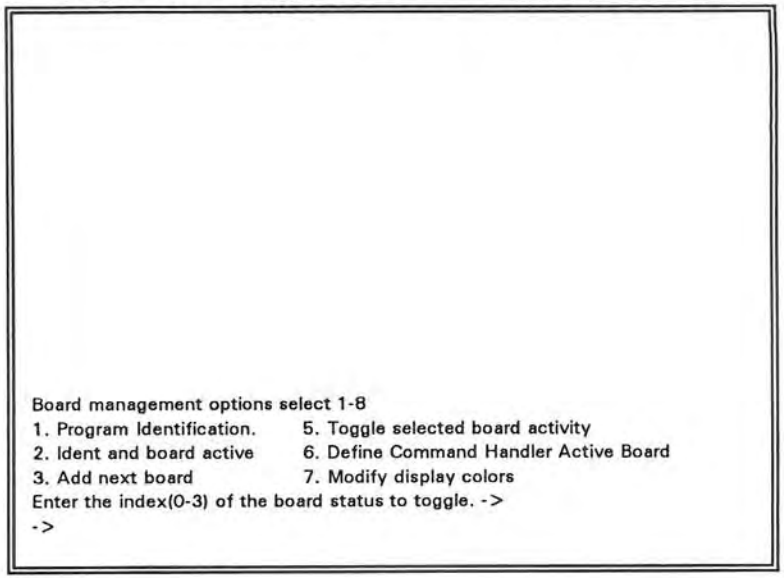
CAUTION!

When using hardware interrupts, ensure that the one selected is not used by another device. If a used interrupt is selected, unpredictable and destructive results may occur.

The following table lists usually assigned hardware interrupts.

Number	Address	Name	Owner
IRQ 00	115D : 003C	Timer Output 0	DOS System Area
IRQ 01	115D : 0045	Keyboard	DOS System Area
IRQ 02	115D : 0057	[Cascade]	DOS System Area
IRQ 03	05CF : 324A	COM2	DOS System Area
IRQ 04	115D : 0087	COM1	DOS System Area
IRQ 05	115D : 009F	LPT2	DOS System Area
IRQ 06	115D : 00B7	Floppy Disk	DOS System Area
IRQ 07	0070 : 06F4	LPT1	DOS System Area
IRQ 08	115D : 0052	Realtime Clock	DOS System Area
IRQ 09	F000 : EECF	Reserved	BIOS
IRQ 10	115D : 00CF	Reserved	DOS System Area
IRQ 11	115D : 00EF	Reserved	DOS System Area
IRQ 12	115D : 00FF	Reserved	DOS System Area
IRQ 13	F000 : EED8	Coprocessor	BIOS
IRQ 14	115D : 0117	Fixed Disk	DOS System Area
IRQ 15	F000 : FF53	Reserved	BIOS

Figure 10. Toggle Selected Board Activity

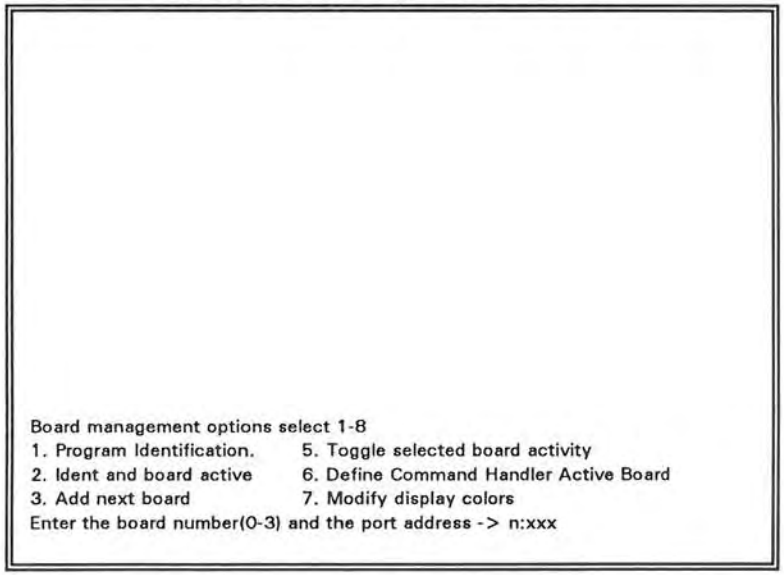


The display immediately returns to that of Figure 2.

4.1.7.6 Define Command Handler Active Board (6)

The board indicated as recipient of all command handler commands is set through this command. Designation of this board is indicated by flashing the index and port address on the screen.

Figure 9. Change Port Address



The display immediately returns to that of Figure 2 after the board number and port address are entered.

4.1.7.5 Toggle Selected Board Activity (5)

The state of the designated board is inverted and the status line is redisplayed for the altered state.

7.0 SYNCHRONIZATION

Synchronization signals

All input and output signals must be compatible with the following logic:

Input:

START = Logic LOW to HIGH transition, 50 μsec. pulse, min., on the POSITIVE input; inverse of this on the NEGATIVE input.

Output:

START = Logic LOW to HIGH transition, 50 μsec. pulse, min., on the POSITIVE output; inverse of this on the NEGATIVE output.

The Sync In and Sync Out signals use differential receivers and drivers which are compatible with RS-422 specifications.

The pin assignments are as shown in section 5.7.

Synchronization

Synchronization defines and controls the precise time that an InsideTrak instrument measurement cycle will start and thereby controls the tracking output from an application system point of view. The InsideTRAK instrument

has three distinct synchronization modes that are controlled by the "y" commands and are defined as:

MODE	COMMAND
Internal Sync	y0
External Sync	y1
Software Sync	y2

- Internal Sync

In the Internal Sync mode (y0 command), each measurement cycle of the InsideTRAK instrument starts immediately after the previous cycle ends. The instrument update rate is slightly greater than 60 Hz and cycle-to-cycle variations on the order of microseconds are possible in this mode. Only the "y0" command is required to initiate the Free-run mode and no input is required for the instrument's SYNC connector.

- External Sync

The External Sync mode (y1 command), allows you to define when the InsideTRAK instrument's measurement cycle will start. This mode may be used to synchronize other peripheral instrumentation to the InsideTRAK data collection cycle or to slow the InsideTRAK to a known and desired rate. To initiate the External Sync mode, an external signal as detailed above must be input to the SYNC connector and the "y1" command issued.

installed or not. Such reexamined status appears on the status line. See Figures 1 and 2.

4.1.7.3 Activate Next Board (3)

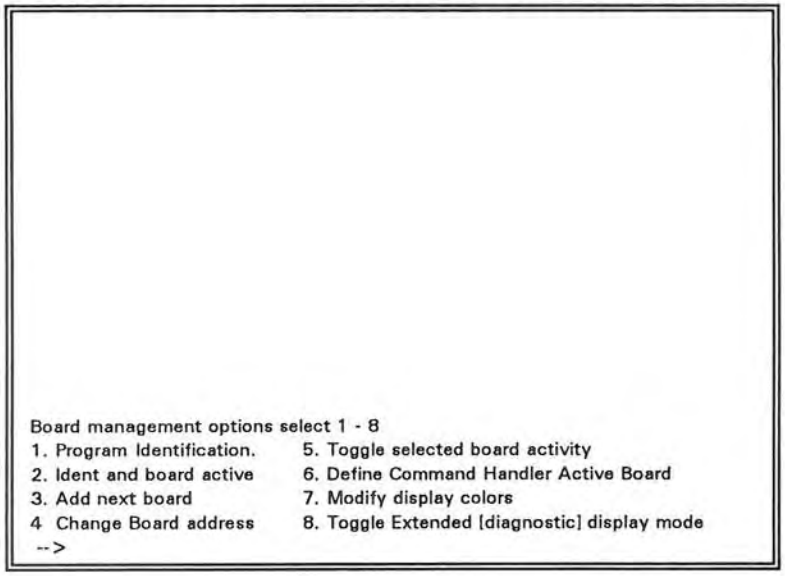
This option sets the next sequential board currently in inactive state to active state. The board may or may not be present. No check on the validity of the port address is made. The screen is displayed as in Figure 9. After selecting option 3, the display shows the status and menu bars as in Figure 2.

4.1.7.4 Change Port Address (4)

The port index is indicated. The existing port address is displayed, and the modified port address is displayed in bold as entered on the screen. Following entry the board is set to active state.

4.1.7 Bus And Board Management (F4)

Figure 8. Main Menu Bus and Board Management



4.1.7.1 Program Identification (1)

This option displays the program version on the screen. The data are cleared after a short wait and the status and menu bars appear. See Figures 1 and 2.

4.1.7.2 Program ID And Activity Status (2)

This option designates the display of data on the screen. The data is cleared after an appropriate wait. The program exercises the designated ports to determine if the boards are

. Software Sync

The Software Sync mode (y2 command) also allows you to define when the InsideTRAK instrument's measurement cycle will start using a software command. The Software Sync is generated by a dummy byte output to Address Offset 3.

NOTE: For synchronization connections and examples see Appendix C.

WARNING

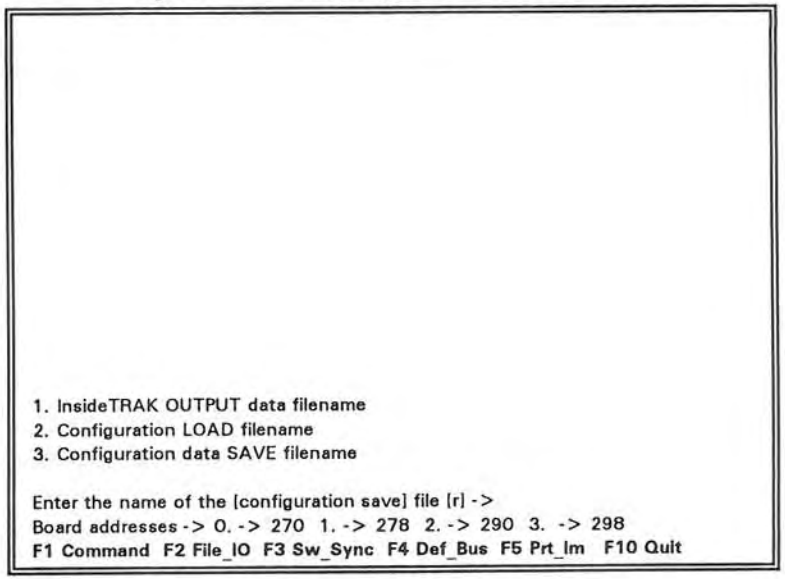
ONCE A MEASUREMENT CYCLE HAS BEEN STARTED VIA RECEIPT OF AN EXTERNAL SYNC PULSE FOLLOWING ISSUANCE OF THE "y" COMMAND, InsideTRAK IGNORES ANY FURTHER SYNC PULSES UNTIL THE MEASUREMENT CYCLE IS COMPLETE. ADDITIONALLY, IF AND WHEN YOU WANT TO DISCONTINUE USING THE EXTERNAL SYNC MODE, YOU MUST ISSUE THE INSTRUMENT EITHER A "y0" OR A "y2" COMMAND. FAILURE TO DO THIS WILL CAUSE THE INSTRUMENT NOT TO RESPOND AND YOU WILL NOT BE ABLE TO EITHER SEND COMMANDS OR RECEIVE DATA.

8.0 INSTRUMENT OPERATION

After installing the SCM and the SEB, selecting the hardware interrupt, setting the required/desired I/O address via S1 and plugging any SCM cable into JP7, re-assemble your PC chassis and connect the TFM, Transmitter and Receiver(s). You may now operate the InsideTRAK using the included Interface Program Diskette. Operation of the InsideTRAK instrument consists of issuing commands and collecting the selected position and/or orientation output data for use. A complete listing of the InsideTRAK System Control and Configuration Commands is contained in the Interface Control Document for PC-ISA Bus. The entirety of this document resides in Appendix A.

When option [3], configuration SAVE, is designated, the screen becomes:

Figure 7. Configuration File Save



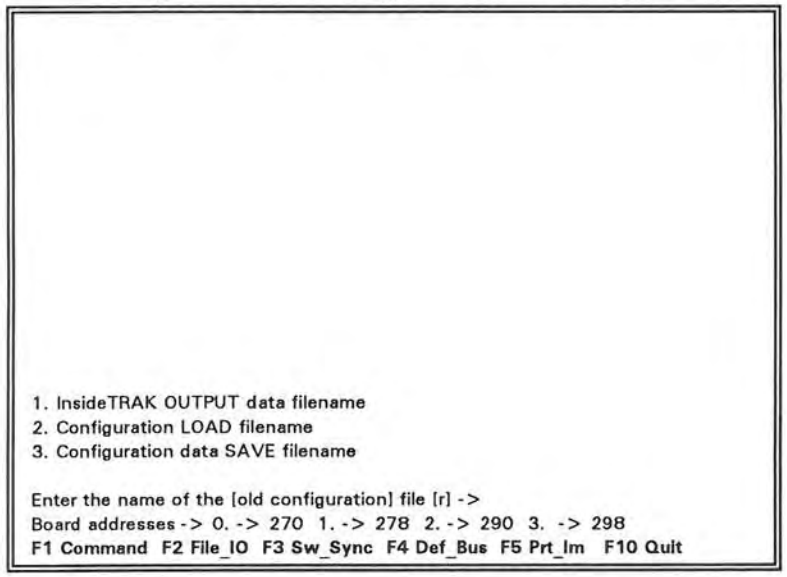
4.1.6 Software Sync (F3)

Pressing F3 sends a software sync signal to the board designated as active with the input command handler.

(Refer to Synchronization Modes in Appendix A - "y" command.)

If option [2], Configuration LOAD, is designated, the screen changes to:

Figure 6. Configuration File Load



9.0 WARRANTY

9.1

Polhemus Incorporated (PI) warrants that the Systems shall be free from defects in material and workmanship for a period of one year from the date ownership of the System passed from PI to Buyer. PI shall, upon notification within the warranty period, correct such defects by repair or replacement with a like serviceable item at PI's option. This warranty shall be considered void if the System is operated other than in accordance with the instructions in PI's User Manual or is damaged by accident or mishandling. Parts or material which are clearly expendable or subject to normal wear beyond usefulness within the warranty period such as lamps, fuses, etc., are not covered by this warranty.

9.2

In the event any System or portion thereof is defective, Buyer shall, within the warranty period, notify PI in writing of the nature of the defect, remove the defective parts and, at the direction of PI, ship such parts to PI. Upon determination by PI that the parts or Systems are defective and covered by the warranty set forth above, PI, at its option shall repair or replace the same without cost to Buyer. Buyer shall pay all charges for transportation and delivery costs to PI's factory for defective parts where directed to be sent to PI, and PI shall pay for transportation

costs to Buyer's facility only for warranty replacement parts and Systems. Removed parts covered by claims under this warranty shall become the property of PI.

9.3

In the event that allegedly defective parts are found not to be defective, or not covered by warranty, Buyer agrees that PI may invoice Buyer for all reasonable expenses incurred in inspecting, testing, repairing and returning the Systems and that Buyer will pay such costs on being invoiced therefor. Buyer shall bear the risk of loss or damage during transit in all cases.

9.4

Any repaired or replaced part or System shall be warranted for the remaining period of the original warranty or thirty (30) days, whichever is longer.

9.5

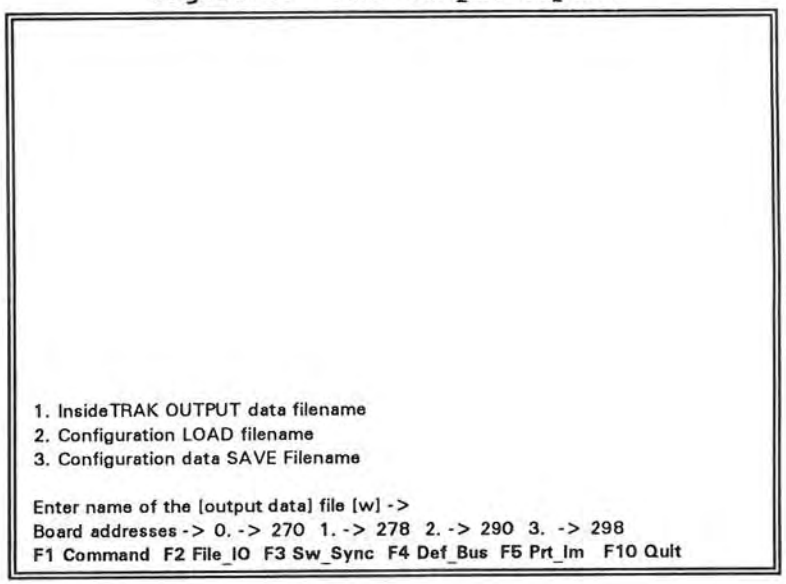
Warranties shall not apply to any Systems which have been:

(a) repaired or altered other than by PI, except when so authorized in writing by PI.
(b) used in an unauthorized or improper manner, or without following normal operating procedures; or
(c) improperly maintained and where such activities in PI's sole judgement, have

attempt is abandoned. Enter a numeric option. The limit of seven attempts is used here as well.

When OUTPUT data file [1] is entered the screen changes to:

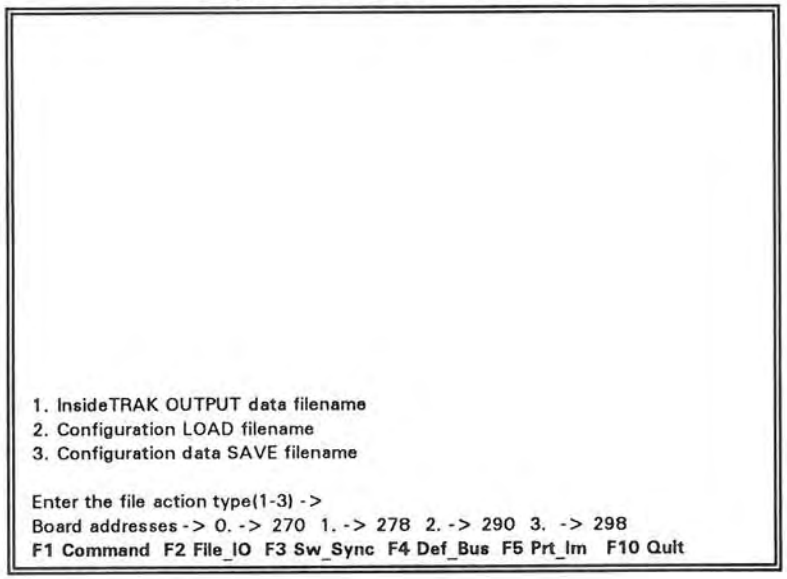
Figure 5. File Output Capture



4.1.5 File IO (F2)

The initial file I/O data screen looks like:

Figure 4. File I/O Menu



Next, the operator is cued to enter an option: For file option 1, if the output is in progress, you are prompted if you really mean to close the data file. On write [w] option, if you are attempting to overwrite an existing file you are prompted for actions of 1. overwrite the file, 2. append to the file, or 3. to reenter another file name. For option 2, if a non-existent read [r] file is designated, up to seven tries are made to obtain a file before the

adversely affected the Systems. Neither shall warranties apply in the case of damage through accidents or acts of nature such as flood, earthquake, lightning, tornado, typhoon, power surge or failure, environmental extremes or other external causes.

9.6

PI does not warrant and specifically disclaims the warranty of merchantability of the products or the warranty of fitness of the products for any particular purpose. PI makes no warranties, express or implied, except of title and against patent infringement, other than those specifically set forth herein.

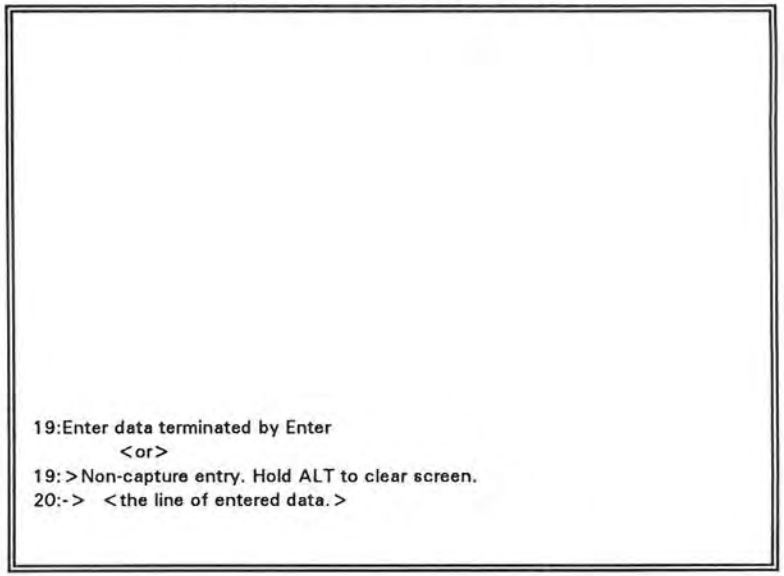
9.7

In no event shall PI be liable under any circumstances for special incidental or consequential damages, including, but not limited to loss of profits or revenue. Without limiting the foregoing, PI's maximum liability for damages for any cause whatsoever, exclusive of claims for patent infringement and regardless of the form of the action (including but not limited to contract negligence or strict liability) shall be limited to buyer's actual direct damages, not to exceed the price of the goods upon which such liability is based.

10.0 INDEMNITY AGAINST PATENT INFRINGEMENT

PI shall have the right at its own expense, to defend or at its option to settle, any claim, suit or proceeding brought against Buyer on the issue of infringement of any United States patent by any product, or any part thereof, supplied by PI to Buyer under this Agreement. PI shall pay, subject to the limitations hereinafter set forth in this paragraph, any final judgment entered against Buyer on such issue in any such suit or proceeding defended by PI. PI at its sole option shall be relieved of the foregoing obligations unless Buyer notified PI promptly in writing of any such claim, suit or proceedings, and at PI's expense, gave PI proper and full information and assistance to settle and/or defend any such claim, suit or proceeding. If the product, or any part thereof, furnished by PI to Buyer becomes, or in the opinion of PI may become, the subject of any claim, suit or proceeding for infringement of any United States patent, or in the event of an adjudication that such product or part infringes any United States patent, or if the use, lease or sale of such product or part is enjoined, PI may, at its option and its expense: (a) procure for Buyer the right under such patent to use, lease or sell, as appropriate, such product or part, or (b) replace such product or part, or (c) modify such product, or part, or (d) remove such product or part and refund the aggregate payments and transportation costs paid therefore by the Buyer less a reasonable sum for use, damage and obsolescence. PI shall have no liability for any infringement arising from: (i) the combination of such product or part with any

Figure 3. Command Menus.



InsideTRAK board; others are used strictly by the PC resident program; still others need to be sent to both to keep the system in synchronization.

The term capture is used for commands used by the PC (intercepted by or captured by the PC). The term non-capture is used for commands not kept (not captured) by the PC but sent along to the InsideTRAK board for its use.

Captured commands are entered via the F1 function key. Non-captured commands are entered without the F1 prefix.

Two formats are output here: When capture is selected via F1, line 19 contains:

Enter data terminated by Enter

line 20 will contain the line of entered data.

If data is entered without designating it for capture by the interface program line 19 contains:

Non-capture entry - hold ALT to clear screen.

Line 20 contains the symbols ->x , where 'x' indicates the printable character entered.

other product or part whether or not furnished to Buyer by PI, or (ii) the modification of such product or part unless such modification was made by PI, or (iii) the use of such product or part in practicing any process, or (iv) the furnishing to Buyer of any information, data, service or application assistance. Buyer shall hold PI harmless against any expense, judgment or loss for infringement of any United States patents or trademarks which results from PI's compliance with Buyer's designs, specifications or instructions. PI shall not be liable for any costs or expense incurred without PI's written authorization and in no event shall PI's total liability to Buyer under, or as a result of compliance with, the provisions of this paragraph exceed the aggregate sum paid to PI by Buyer for the allegedly infringing product or part, exclusive of any refund under option (4) above. The foregoing states the entire liability of PI, and the exclusive remedy of Buyer, with respect to any actual or alleged patent infringement by such product or part.

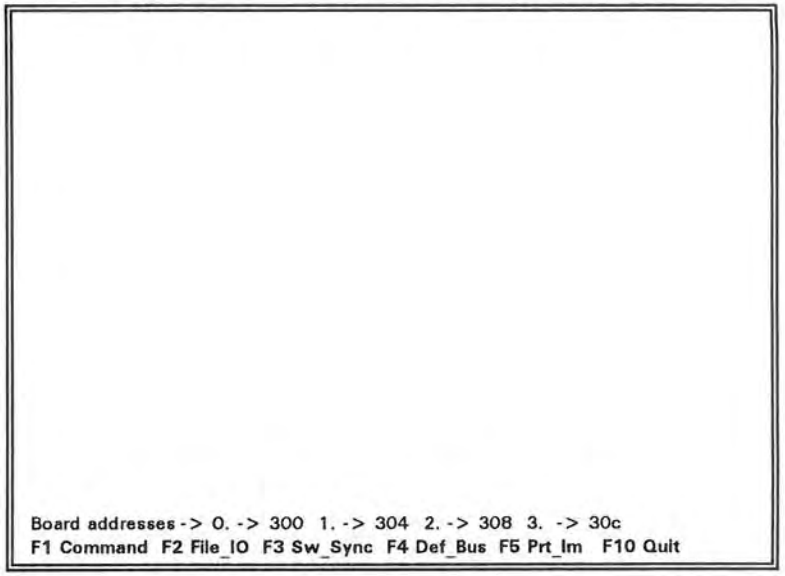
11.0 CUSTOMER SERVICE

If you encounter any problems with your InsideTRAK instrument, help is just a telephone call away. Call 802/655-3159 and ask for Customer Service. For the most part, our Customer Service engineers can handle your problems over the telephone and get you back into the fast lane right away. If the problem requires repair of your instrument, the Customer Service engineer will issue you a Return Merchandise Authorization (RMA) number. It is a good idea to keep the original shipping container for your InsideTRAK instrument in the event that the instrument may require repair. Please do not return any instrument without an RMA number as it will not be accepted. If your instrument is still under warranty, Polhemus will repair it free of charge according to the provisions of the warranty as stated in Section 9 of this document. The proper return address is:

Polhemus Incorporated
1 Hercules Drive
P.O. Box 560
Colchester, Vermont 05446

Telephone (voice): (802) 655-3159
Telephone (FAX): (802) 655-1439

Figure 2. Status And Main Menu Bar



NOTE: In most cases, an escape from an erroneous menu selection or incorrect data entry may be achieved by pressing the ESC key or the ESC key followed by the ENTER key.

4.1.4 Command Menus (F1)

To understand the command types, it must be kept in mind that the tracking system using the PC interface program (or program modules as they are used for customized interfaces) is composed of the InsideTRAK board and a PC, each operating somewhat independently using its own processor and each with its own functional and output options. Some commands entered via the PC keyboard can be passed through directly to the

well as normal intensity characters. The brightly illuminated data are the port addresses of the installed boards in hexadecimal form. Flashing data indicates the index of the board active for the command handler. Figure 2 shows the position of the status line.

4.1.3 Menu Bar Line

The menu bar on line 25 indicates the items selectable at the main level. No capability exists to use menu keys to jump back out of several levels to the main level. Rather, the function menu keys are one directional keys to take you to the sub-menu selections. Numeric key-ins are used for sub-menus. In extended display mode (F4, 8) on line 24 of the screen, the current/last selected function/menu option is shown along with the number of 16 bit words read off the bus.

While some reverse video functionality is used to display some data, this manual will not attempt to display that mode.

The ALT key toggles between displaying and not displaying the main menu bar.

OPM3792-001
December 1993

APPENDIX A

InsideTRAK
SYSTEM CONTROL/CONFIGURATION COMMANDS AND OUTPUT RECORDS

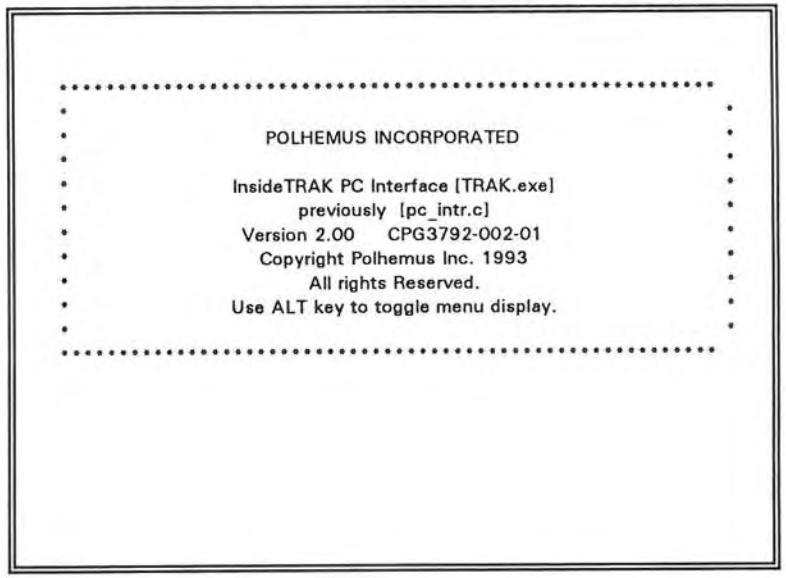
INTERFACE CONTROL DOCUMENT

For PC-ISA BUS

4.1.1 Start-up Identification Menu

At program start-up the following menu appears for a short period of time. It can be re-displayed by options within the file management menus.

Figure 1. Identification Screen.



After five seconds, the screen displays the status line and menu bar as in Figure 2.

4.1.2 Board Status Menu Line

The Board status menu is contained on line 24. On properly configured monochrome monitors and color monitors, the program will generate fields of highlighted or bright characters as

Table 1. Screen Partitioning

Lines	Board	Station
1-3	0(Master)	1
4-5	0	2
6-7	1	1
8-9	1	2
10-11	2	1
12-13	2	2
14-15	3	1
16-17	3	2
19-23	Screen Management Menus and Queries	
24	Board Status	
25	Main menu bar and last selected main menu item.	

Screen colors are white on green background, except after changing the board address. Many specific actions will restore the screen colors. Monochrome display operation is also supported.

4.0 Running The Program

Having copied the program to your hard disk, from the directory where installed, type:

trak<>

4.1 Menus

A variety of menus appear from initialization through a structured menu set. The initialization menu appears on start-up as well as in menu selections 1 and 2 in the bus management set function key F4. The screen erases itself after a short time.

INTRODUCTION

Chapter 1 of this appendix describes the set of available commands for configuring the state of an InsideTRAK Device. Commands are also included for controlling their performance characteristics. All command strings are written to a device board configured to the PC system as an I/O device and consist of ASCII character strings. Chapter 2 is a complete description of all output records. Chapter 3 is an explanation and listing of BIT error codes and their meanings.

TABLE OF CONTENTS

1.0 Introduction

This manual describes setup, function, options, and trouble shooting of the Polhemus InsideTRAK Interface Program. The program is a module for a PC compatible computer, running DOS, that provides a basis for building program(s) to use the InsideTRAK system as desired. The InsideTRAK is the 16 bit ISA bus resident hardware board capable of operating as a three dimensional tracking device.

2.0 Program Setup

The interface program may be run directly off the distributed floppy disk. However, it is recommended that you copy the diskette to a second diskette or place the contents of the diskette on a hard drive. INSTALLA.BAT or INSTALLB.BAT are provided for installation on a hard drive. See the file READ.ME on the diskette or the Getting Started section of this manual.

3.0 Screen Segmentation

The screen is partitioned for different usages.

FIGURES

TABLES

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LIST OF FIGURES

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FORMAT NOTATION and CONVENTIONS

Use the following format notation to enter commands:

[] Items shown inside square brackets are optional. To include optional items, type only the information inside the brackets. Do not type the brackets.

{} Items shown inside braces are optional only when requesting a data record. These items must be specified when entering other parameters in the command. Do not type the braces.

<> Represents an ASCII carriage return. Whenever shown this value must be present to terminate the command sequence.

... An ellipsis indicates that you can repeat an item.

, A comma represents a delimiter in a list of optional parameters. The comma must be present for those parameters which are omitted except for the case of trailing commas. For example,

Xs,p1,,,p4<>

is the proper command format when omitting parameters p2 and p3. Commas following the parameter p4 are not required if parameter p5 is omitted.

| A vertical bar means either/or. Choose one of the separated items and type it as part of the command. For example,

ON|OFF

indicates that you should enter either ON or OFF, but not both. Do not enter the vertical bar.

^ Denotes the Ctrl key. Commands such as ^K, require the user to combine the Ctrl key and the character following (ie. K), as the command input.

NOTES:

(1) For those commands involving an optional list of parameters, if some of the parameter values are omitted the current system retained value of that parameter is used in its place.

(2) The RELATIVES field contains a list of those commands which provide related information to the system.

(3) Throughout this document, the term "receiver" refers to each possible receiver (1 or 2) connected to each InsideTRAK board.

(4) The transmitter attached to the Master board is always numbered one (1).

(5) The term station is a transmitter-receiver pair. In an InsideTRAK, the two receivers

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APPENDIX B

InsideTRAK Interface Program

User's Manual

on any board, paired with the one available transmitter on a master board, are assigned station numbers one and two (1-2). Each board uses this annotation.

(6) Serial numbers of devices are specified, where required in a command, with a preceding device type identification as follows:

t transmitter
r receiver

thus a standard transmitter serial number 99999 would be entered as t99999

(7) All commands and alphabetic parameters are case sensitive. They must be entered in upper or lower case as defined for particular command entries.

The following are specific output notations:

The notation R(Sxx.xxxb) represents the ASCII output format for the specific data element, where:

R is the repeat count, and what follows in parenthesis is repeated R times
S is the sign byte, either +, -, or space (for +)
x is a decimal digit (0..9).
H is a hexadecimal digit (0..F).
. is the decimal point
b is a Blank

Example:

A format 3(Sx.xxxxb), would be output as:
-1.1111 2.2222 -3.3333

The notation "IEEE-32Float" refers to ANSI/IEEE Standard for Binary Floating-Point Arithmetic, 754-1985, format of data. This is defined in the standard as:

	MSB				LSB
	Bit 31	30-23	22-0		
Polhemus	Sign	exponent	fraction		
I/O					
IEEE	by3		by2	by1	by0
Binary	Bit 7	6-0	7 6-0	7-0	7-0

The IEEE floating-point format uses sign magnitude notation for the mantissa, and an exponent offset by 127. In a 32-bit word representing a floating-point number, the first bit is the sign bit. The next 8 bits the exponent, offset by 127 (ie. the actual exponent is e - 127). The last 23 bits are the absolute value of the mantissa with the most significant 1 implied. The decimal point is after the implied 1, or in other words the mantissa is actually expressed in 24 bits. In the normal case an IEEE value is expressed as:

$(-1)S * (2^{(e-127)}) * (01.f)$ If $0 < e < 255$

j movement of receiver towards sensor too rapid for AGC

u operating outside mapped bounds

x receiver outside defined motion box (V command)

y orientation angles outside allowed angular envelope (Q command)

3.2.5 Error codes which may be caused by incorrect data entry of operating parameters:

X transmitter characterization matrix - consult factory

Y receiver characterization matrix - consult factory

t compensation structure - consult factory

3.2.6 Error correction.

As indicated above, try to correct the error by avoiding proximity to metallic objects or by redefining the operating configuration or checking connections. If these efforts fail to correct the error, you may have a defective part. Consult the factory for further analysis or for any unlisted error codes.

3.0 BIT

3.1 Introduction to BIT.

Built in test(BIT) is a set of routines that perform hardware and software tests on the InsideTRAK system. Correct operation causes no error codes to be generated. Failures/problems detected cause ASCII error codes to be generated. These may indicate failed equipment, improper conneciton, high magnetic distortion environments or improper system operating parameters caused by incorrect data entry or by data corruption in your PC files.

3.2 Error indications and possible corrections.

3.2.1 Error codes which may be corrected by checking transmitter connections:

A, B, C, G, H, I, a, b, c

3.2.2 Error codes which may be corrected by checking receiver connections:

k, l

3.2.3 Error codes which may be caused by distortion environments (proximity of large metal objects too great):

A, B, C, G, H, I, a, b, c

3.2.4 Error codes which may be caused by incorrect physical setup relative to entered configuration:

In special cases:

(-1)S * 0.0	If e = 0 and f = 0
(-1)S * ($2^{(-126)}$) * (0.f)	If e = 0 and f <> 0 (denormalized)
(-1)S * infinity	If e = 255 and f 0 (infinity)
NaN (not a number)	If e = 255 and f <> 0

The lowest physical address for a byte is a0; a1 has address a0+1, etc. The least significant byte of data is b0, with b3 the most significant byte. For IEEE FP output from InsideTRAK, the byte output sequence is b0, b1, b2, & b3.

a0	a1	a2	a3	
b0	b1	b2	b3	80X86

In the format column of Chapter 2, A means ASCII, I means integer, and the number following A or I is the number of such characters. For example, A3 means 3 character ASCII format.

The notation "S1-16INT" signifies that the output is a 16 bit format with a final value range of +1.0 to - 1.0. The output 16 bit integer is multiplied by 3.0519E-05 (or 1/32767) to result in a floating point value.

The notation "S2-16INT" signifies that the output is a 16 bit format with a final value range of +180.00 to -180.00 degrees. The output 16 bit integer is multiplied by 5.493332E-03 (or 180/32767) to result in a floating point value in degrees.

The notation "S3-16INT" signifies that the output is a 16 bit format with a final value range of +300.0 to -300.0 cm. The output 16 bit integer is multiplied by 9.155553E-03 (or 300/32767) to result in a floating point value in centimeters. The output 16 bit integer can be multiplied by 3.604548E-03 (or (300/2.54)/ 2767) to result in a floating point value in inches.

The field "INITIATING COMMAND" in the description of the output record represents the console port input command which will cause the output record to be generated. Note that record identifiers and initiating commands are case sensitive as shown on each record description.

All angles are represented in degrees. All X, Y, and Z units for command input or command data responses are in centimeters or inches, depending on the system configuration (see the Command Input/Output Units commands "U" and "u").

CHAPTER THREE - BIT PROCESSING AND CODES

COMMAND ERROR

```
**********************************************

SUB-RECORD IDENTIFIER .... *
INITIATING COMMAND ....... all invalid commands

----------------------------------------------

byte(s)   Identification

 1-7  ... "*ERROR*
 8-?? ... Erroneous command as it was input
??-+8 ... "*ERROR*
??-?? ... Error code from following list:
          -1   Required field missing
          -2   Required numeric is non-numeric
          -3   Value is outside required range
          -4   Specified frequency not
               hardware configured
          -99  Undefined input - cannot identify
               command
??-+3 ... "*PS"
??-?? ... Character position in the input record
          - note numbering starts 0,1,2...
??-+3 ... "*FL"
??-?? ... Field number causing the error - note
          numbering of the field is 0,1,2...
          and starts at '0' following the
          command identifier.
??-+3 ... "*ST"
??-?? ... Number of the affected system station
          less 1, ie. this value ranges from
          0-1, stations are numbered in
          commands as 1-2.
    ??... NULL Filler (If Required)

**********************************************
```


If required, output records are filled with a null character in the final 8 bits of output to form a complete (and therefore known) 16 bit words of output.

CHAPTER ONE - CONTROL COMMANDS

SYNCHRONIZATION MODE

****

SUB-RECORD IDENTIFIER .... y
INITIATING COMMAND ..... y

---

byte(s)	Identification	Format
1	Record type, "2"	A1
2	Blank	A1
3	Sub-record type "y"	A1
4	Synchronization mode	I1
	0 - Internal	
	1 = External	
	2 = Software	
5-6	Carriage return, line feed	

****

POSITION FILTER PARAMETERS

****

SUB-RECORD IDENTIFIER x
INITIATING COMMAND x

---

byte(s)	Identification	Format
1	Record type, "2"	A1
2	Blank	A1
3	Sub-record type "x"	A1
4-10	Filter sensitivity	bSx.xxx
11-17	Floating filter low value	bSx.xxx
18-24	Floating filter high value	bSx.xxx
25-31	Transition rate maximum	bSx.xxx
32-33	Carriage return, line feed	
34	NULL Filler	

****

ALIGNMENT

Configuration: All

Description: The alignment commands allow the user to define an origin from which the X, Y, Z measurements are referenced, and to define a measurement plane. For example, if there is a sloped surface to measure and it is necessary to have the X, Y, Z outputs measured with respect to the reference frame defined by this sloped surface, then the alignment commands allow you to do this.

Alignment data consists of the coordinates, in the transmitter reference frame, of three non-collinear points in space that are used to define the "alignment reference frame." The first point is the origin of the alignment reference frame. A line from the origin through the second point defines the positive X-axis of the alignment reference frame. The plane defined by all three points defines the XY-plane of the alignment reference frame; the positive Y-direction being from the X-axis toward the third point. The positive Z-axis is determined by the "right-hand

rule" convention for coordinate systems (see Fig. 1-1).

The units of the coordinates are interpreted according to the value of UNITS as set by the "U" and "u" command.

Commands: A, R

ATTITUDE FILTER PARAMETERS

****

SUB-RECORD IDENTIFIER v
INITIATING COMMAND v

---

byte(s)	Identification	Format
1	Record type, "2"	A1
2	Blank	A1
3	Sub-record type "v"	A1
4-10	Filter sensitivity	bSx.xxx
11-17	Floating filter low value	bSx.xxx
18-24	Floating filter high value	bSx.xxx
25-31	Transition rate maximum	bSx.xxx
32-33	Carriage return, line feed	
34	NULL Filler	

****

RECEIVER BORESIGHT ANGLES

****

SUB-RECORD IDENTIFIER .... s
INITIATING COMMAND ..... s

---

byte(s)	Identification	Format
1 ...	Record type, "2"	A1
2 ...	Station Number	A1
3 ...	Sub-record type "s"	A1
4-11 ...	Azimuth mounting frame angle	Sxxx.xxx
12-19 ...	Elevation mounting frame angle	Sxxx.xxx
20-27 ...	Roll mounting frame angle	Sxxx.xxx
28-29 ...	Carriage return, line feed	
30 ...	NULL Filler	

****

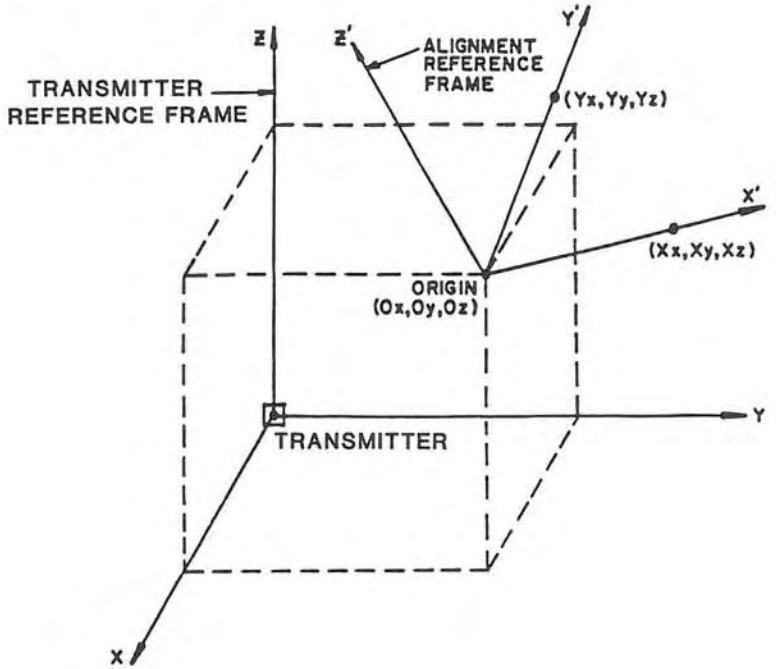

Figure 1-1 System Alignment

ALIGNMENT REFERENCE FRAME

****

Syntax: Astation,[Ox],[Oy],[Oz],[Xx],[Xy],
[Xz],[Yx],[Yy],[Yz]<>

Purpose: The alignment command defines a reference frame to which all position and orientation output data is referred.

NOTE: This command operates incrementally. If the command is entered and the user then changes his/her mind, the 'R' command must be used to reset the alignment reference frame BEFORE the command is re-entered. This is ESPECIALLY IMPORTANT to remember if the user makes an error and wants to correct the erroneous input. The command is useful in this incremental mode ONLY TO THE MOST SOPHISTICATED user, and should not be attempted unless you have the expertise to understand and use the results. The command parameters are:

station — to specify the relevant transmitter / receiver pair.

Ox,Oy,Oz — the cartesian coordinates of the origin of the new reference frame.

TRANSMITTER MOUNTING FRAME

****

SUB-RECORD IDENTIFIER .... r
INITIATING COMMAND ..... r

---

byte(s)	Identification	Format
1	Record type, "2"	A1
2	Station Number	A1
3	Sub-record type "r"	A1
4-11	Azimuth mounting frame angle	Sxxx.xxx
12-19	Elevation mounting frame angle	Sxxx.xxx
20-27	Roll mounting frame angle	Sxxx.xxx
28-29	Carriage return, line feed	
30	NULL Filler	

****

ACTIVE STATION STATE

****

SUB-RECORD IDENTIFIER 1
INITIATING COMMAND 1

---

byte(s)	Identification	Format
1	Record type, "2"	A1
2	Station number	A1
3	Sub-record type "1"	A1
4	Station 1 = 1 if active, else 0	A1
5	Station 2 = 1 if active, else 0	A1
6-7	Carriage return, line feed	
8	NULL Filler	

****

Xx,Xy,Xz the coordinates of the point defining the positive direction of the X-axis of the new reference frame.

Yx,Yy,Yz the coordinates of a third point that is in the positive Y direction from the X_axis.

If all of the optional parameters are omitted the command returns the current coordinate values to the host.

Relatives: R

****

RESET ALIGNMENT REFERENCE FRAME

****

Syntax: Rstation<>

Purpose: This command resets the alignment reference frame for the specified station to the station reference frame. It provides an easy way to re-align the reference frame to the factory default values. The command parameter is defined as:

station the number of the station to be reset.

Relatives: A

****

DAC VALUE

****

SUB-RECORD IDENTIFIER .... g
INITIATING COMMAND ..... g

---

byte(s)	Identification	Format
1	Record type, "2"	A1
2	Transmitter Number	A1
3	Sub-record type "g"	A1
4-13	DAC value (Decimal b HEX)	I5bH4
14-15	Carriage return, line feed	
16	NULL Filler	

****

POSITION OPERATIONAL ENVELOPE

****

SUB-RECORD IDENTIFIER V
INITIATING COMMAND V

---

byte(s)	Identification	Format
1	Record type, "2"	A1
2	Station number	A1
3	Sub-record type "V"	A1
4-11	Maximum x-coordinate value	Sxxx.xxx
12-19	Maximum y-coordinate value	Sxxx.xxx
20-27	Maximum z-coordinate value	Sxxx.xxx
28-35	Minimum x-coordinate value	Sxxx.xxx
36-43	Minimum y-coordinate value	Sxxx.xxx
44-51	Minimum z-coordinate value	Sxxx.xxx
52-53	Carriage return, line feed	
54	NULL Filler	

****

BORESIGHT

Description: The boresight function allows one to designate any receiver orientation as the zero orientation point.

For example, the receiver may be mounted on a person's head to measure where it is pointing. When the user's head is looking at a given object, he may want the system angular outputs to be zero. The user can designate this receiver orientation as the zero orientation by giving the boresight command. This results in azimuth, elevation, and roll outputs of zero at this orientation. As the user's head moves away from the boresight point, the orientation angles are still measured in the designated reference frame, with the zero points shifted to the point where the boresight occurred.

If the alignment command "A" has been previously invoked, the results of boresight are unpredictable and therefore the combination should be avoided.

Commands: B, G, b, r, s

Default: The zero orientation condition occurs when the receiver

orientation corresponds to the
transmitter orientation.

BIT INFORMATION

****

SUB-RECORD IDENTIFIER .... T
INITIATING COMMAND ..... T

---

byte(s)	Identification	Format
1	Record type, "2"	A1
2	Blank	A1
3	Sub-record type "T"	A1
4-6	BIT number	I3
7-??	BIT information (Factory Use)	A??
??-??	Carriage return, line feed	
??	NULL Filler (If Required)	

****

```
22-53 ... System Identification      A32
          (Value is "     InsideTRAK CPG2047
          -001-01  "
54-55 ... Carriage return, line
          feed
   56 ... NULL Filler

************************************************
```


BORESIGHT

****

Syntax: Bstation<>

Purpose: This command causes the system to redefine the specified station line of sight values as the new zero reference line of sight. This results in azimuth, elevation and roll outputs equal to the boresight reference values at the current orientation. The system default boresight matrix is the identity. The command parameter is defined as:

station the number of the station to be boresighted.

Relatives: G, b, r, s

****

BORESIGHT REFERENCE ANGLES

****

Syntax: Gstation,[aref],[eref],[rref]<>

Purpose: This command establishes the boresight reference angles for a particular station. When the system is subsequently boresighted, the line-of-sight vector will assume these values. If all the optional parameters are omitted, the system returns the boresight reference angles for the specified station as an output record of type "G". The command parameters are defined as:

station	the number of the station whose reference angles are to be fixed.
aref	the azimuth reference angle.
eref	the elevation reference angle.
rref	the roll reference angle.

The system default boresight reference values are: 0, 0, 0

Relatives: B, b, r, s

****

SYSTEM STATUS

****

SUB-RECORD IDENTIFIER .... S
INITIATING COMMAND ..... S

---

byte(s)	Identification	Format
1	Record type, "2"	A1
2	Station number	A1
3	Sub-record type "S"	A1
4-6	System flags	H3
	LSBit	
	0 ... Output Format (0=ASCII, 1=Binary)	
	1 ... Units (0=Inches, 1=Centimeters)	
	2 ... Compensation (0=Off, 1=ON)	
	3 ... Transmit Mode (0=Non-Continuous, 1=Continuous)	
	4 ... Configuration (Always 1)	
	5 ... 1 = Fastrak Family	
	6-7 ... Always 11	
	8-9 ... Always 11	
	10-11 ... Product (00=Fastrak,01=InsideTRAK)	
	12-23 ... Reserved for future use	
	MSBit	
7-9	BIT error number	I3
10-15	Blank (Reserved for future use)	A6
16-21	Software Version ID "150.00", 150.00 will change as software is revised. For minor revisions xx will increment as in 150.xx. Major revisions will be reflected by an increment of x in 15x.00.	A6

ANGULAR OPERATIONAL ENVELOPE

****

SUB-RECORD IDENTIFIER .... Q
INITIATING COMMAND ..... Q

---

byte(s)	Identification	Format
1	Record type, "2"	A1
2	Station number	A1
3	Sub-record type "Q"	A1
4-12	Maximum azimuth value	Sxxx.xxxb
13-21	Maximum elevation value	Sxxx.xxxb
22-30	Maximum roll value	Sxxx.xxxb
31-39	Minimum azimuth value	Sxxx.xxxb
40-48	Minimum elevation value	Sxxx.xxxb
49-57	Minimum roll value	Sxxx.xxxb
58-59	Carriage return, line feed	
60	NULL Filler	

****

UNBORESIGHT

****

Syntax: bstation<>

Purpose: The system boresight rotation matrix is reset to the identity matrix for the specified station. The command parameter is defined as:

station	the number of the station whose boresight is to be reset.

Relatives: B, G, r, s

****

TRANSMITTER MOUNTING FRAME

****

Syntax: rTransmitter,[A],[E],[R]<>

Purpose: This command provides a means of electronically modifying the mounting frame of the transmitter relative to a particular receiver. This command modifies the values of the transmitter mounting frame coordinates when it is used with an associated receiver. If the optional parameters are omitted, the system returns the current values of the transmitter mounting frame coordinates relative to the associated receiver as an output record of type "r". The command parameters are:

Transmitter	Aways = 1
A	mounting frame azimuth angle in degrees
E	mounting frame elevation angle in degrees
R	mounting frame roll angle in degrees

Relatives: B, G, b, s

****

OUTPUT ITEM LIST

****

SUB-RECORD IDENTIFIER .... O
INITIATING COMMAND ..... O

---

byte(s)	Identification	Format
1	Record type, "2"	A1
2	Station number	A1
3	Sub-record type "O"	A1
4-5	Data item 01 identification	I2
6-7	Data item 02 identification	I2
8-9	Data item 03 identification	I2
.	.	
.	.	
2*n+2 - 2*n+3	Data item n identification	I2
2*n+4 - 2*n+5	Carriage return, line feed	
2*n+6	Null Filler (If required)	

****

HEMISPHERE OF OPERATION

****

SUB-RECORD IDENTIFIER .... H
INITIATING COMMAND ..... H

---

byte(s)	Identification	Format
1	Record type, "2"	A1
2	Station number	A1
3	Sub-record type "H"	A1
4	Blank	A1
4-10	Vector x-component	Sxx.xxx
11-17	Vector y-component	Sxx.xxx
18-24	Vector z-component	Sxx.xxx
25-26	Carriage return, line feed	

****

RECEIVER BORESIGHT ANGLES

****

Syntax: sReceiver,[A],[E],[R]<>

Purpose: This command provides a means of modifying the boresight angles from which the receiver's boresight matrix is re-calculated (ie a boresight of the specified receiver). If all of the optional parameters are missing, the system returns the current values of the specified receiver's boresight angles. The command parameters are:

Receiver	1 or 2
A	boresight azimuth angle in degrees.
E	boresight elevation angle in degrees.
R	boresight roll angle in degrees.

Relatives: B, G, b, r

****

COMPENSATION

Description: Compensation refers to the adjustments that are necessary to the system computations for dynamics of receiver movements (ie filter). The following commands provide a means to adjust parameters required for these compensations.

Commands: v, x

BORESIGHT REFERENCE ANGLES

****

SUB-RECORD IDENTIFIER .... G
INITIATING COMMAND ..... G

---

byte(s)	Identification	Format
1	Record type, "2"	A1
2	Station Number	A1
3	Sub-record type "G"	A1
4-10	Azimuth reference angle	Sxxx.xx
11-17	Elevation reference angle	Sxxx.xx
18-24	Roll reference angle	Sxxx.xx
25-26	Carriage return, line feed	

****

ALIGNMENT REFERENCE FRAME

****

SUB-RECORD IDENTIFIER .... A
INITIATING COMMAND ..... A

---

byte(s)	Identification	Format
1	Record type, "2"	A1
2	Station Number	A1
3	Sub-record type "A"	A1
4-24	Origin coordinates	3(Sxxx.xx)
25-45	Positive X-axis coordinates	3(Sxxx.xx)
46-66	Positive Y-axis coordinates	3(Sxxx.xx)
67-68	Carriage return, line feed	

****

ATTITUDE FILTER PARAMETERS

****

Syntax: v[F],[FLOW],[FHIGH],[FACTOR]<>

(All users)

Purpose: This command establishes the sensitivity, boundary, and transition control parameters for the adaptive filter that operates on the attitude outputs of the tracking system. By means of this command, the user can adjust these parameters to fine-tune the overall dynamic response of any system that includes the tracker as a serial component.

The subject filter is a single-pole low-pass type with an adaptive pole location (i.e, a floating filter "constant"). The pole location is constrained within the boundary values FLOW and FHIGH but is continuously self-adaptive between these limits as a function of the sensitivity parameter F and the sensed (ambient noise plus rotational rate) input conditions. For input "rate" conditions that fall within the adaptive range, the adaptive feature varies the pole location between the FLOW and FHIGH limits so as to maximize the output resolution for static inputs while minimizing the output lag for dynamic inputs. Whenever the input

conditions cause the filter to make a transition to a narrower bandwidth (i.e., increased filtering), the transition rate of the pole location is constrained to a maximum allowable rate by the parameter FACTOR. The functions of the four adjustable parameters and their allowable value ranges are further detailed below. If all of the optional parameters are omitted the current value of each parameter is returned to the user as an output record of type "v". The command parameters are:

F — a scalar value that establishes the sensitivity of the filter to dynamic input conditions by specifying the proportion of new input data to recent average data that is to be used in updating the floating filter "constant".

Default value: 0.0
Allowable range of values: $0 < F < 1$

FLOW — a scalar value that specifies the maximum allowable filtering to be applied to the outputs during periods of

* The system data record contents are specified by the user using the "O" command and may vary from configuration to configuration. Therefore, the specific location of a data item in the output record is not determined until the record contents are defined.
****

SYSTEM DATA RECORD

****

RECORD IDENTIFIER ..... none
INITIATING COMMANDS ..... P, transmit interrupt, or in continuous mode

Item	Byte(s)	Identification	Format
	1	Error code or blank	A1
	2	Station Number	A1
		16-BIT Integer Precision:	
0 or 50	?*	2 NULL characters	A2
1 or 51	?*	Carriage return, line feed	A2
2	?*	x,y,z position cartesian coordinates	3(S3-16INT)
4	?*	az,el,roll Euler orientation angles	3(S2-16INT)
5	?*	X-direction cosines (line-of-sight)	3(S1-16INT)
6	?*	Y-direction cosines (line-of-hear)	3(S1-16INT)
7	?*	Z-direction cosines (line-of-plumb)	3(S1-16INT)
11	?*	Orientation Quaternion (Q0-Q3)	4(S1-16INT)
		32-BIT IEEE Float Extended precision:	
52	?*	x,y,z position cartesian coordinates (cm.)	3(IEEE-32FLOAT)
54	?*	az,el,roll Euler orientation angles (degrees)	3(IEEE-32FLOAT)
55	?*	X-direction cosines (line-of-sight)	3(IEEE-32FLOAT)
56	?*	Y-direction cosines (line-of-hear)	3(IEEE-32FLOAT)
57	?*	Z-direction cosines (line-of-plumb)	3(IEEE-32FLOAT)
61	?*	Orientation Quaternion (Q0-Q3)	4(IEEE-32FLOAT)
		Factory use only:	
8 or 58	?*	X-receiver data	3(IEEE-32FLOAT)
9 or 59	?*	Y-receiver data	3(IEEE-32FLOAT)
10 or 60	?*	Z-receiver data	3(IEEE-32FLOAT)
12 or 62	?*	Self Calibration Data	3(IEEE-32FLOAT)
13 or 63	?*	X-receiver corrected values	3(IEEE-32FLOAT)
14 or 64	?*	Y-receiver corrected values	3(IEEE-32FLOAT)
15 or 65	?*	Z-receiver corrected values	3(IEEE-32FLOAT)

relatively static input conditions.

Default value: 1.0
Allowable range of values:
0 < FLOW < FHIGH

FHIGH — a scalar value that specifies the minimum allowable filtering to be applied to the outputs during periods of highly dynamic input conditions.

Default value: 0.0
Allowable range of values:
FLOW < FHIGH < 1

FACTOR — a scalar value that specifies the maximum allowable transition rate from minimum filtering (for highly dynamic input conditions) to maximum filtering (for relatively static input conditions) by proportionately limiting the incremental difference between successive filter "constant" updates whenever the input conditions effect a transition to a narrower bandwidth.

Default value: 0.0

Allowable range of values:
0 < FACTOR < 1

When the form of the command is v0,1,0,0,<> (default), the effect is to disable the attitude filter. To use this filter, a recommended first trial command is v0.2,0.2,0.8,0.8<> .

Relatives: x

****

CHAPTER TWO - COMMAND OUTPUT RECORDS

ISA BUS RECORDS

This chapter describes the detailed content of the data records output on the system's 16 bit ISA BUS.

BIT INFORMATION

****

Syntax: Tbitnbr[,0]<>

Purpose: This command allows the user to obtain additional information about a particular BIT and/or clear a bit error. The system returns the current BIT information for the specified BIT as an output record of type "T". The parameters are:

bitnbr — The BIT number for which added information is requested.

0 — This parameter, if used, is specified as a 0 (zero). If present the bitnbr specified in the command is reset/cleared.

Relatives: S

****

POSITION FILTER PARAMETERS

****

Syntax: x[F],[FLOW],[FHIGH],[FACTOR]<>

(All users)

Purpose: This command establishes the sensitivity, boundary, and transition control parameters for the adaptive filter that operates on the position outputs of the tracking system. By means of this command, the user can adjust these parameters to fine-tune the overall dynamic response of any system that includes the tracker as a serial component.

The subject filter is a single-pole low-pass type with an adaptive pole location (i.e, a floating filter "constant"). The pole location is constrained within the boundary values FLOW and FHIGH but is continuously self-adaptive between these limits as a function of the sensitivity parameter F and the sensed (ambient noise plus translational rate) input conditions. For input "rate" conditions that fall within the

adaptive range, the adaptive feature varies the pole location between the FLOW and FHIGH limits so as to minimize the output resolution for static inputs while minimizing the output lag for dynamic inputs. Whenever the input conditions cause the filter to make a transition to a narrower bandwidth (i.e., increased filtering), the transition rate of the pole location is constrained to a maximum allowable rate by the parameter FACTOR. The functions of the four adjustable parameters and their allowable value ranges are further detailed below. If all of the optional parameters are omitted, the current value of each parameter is returned to the caller as an output record of type "x". The command parameters are:

F — a scalar value that establishes the sensitivity of the filter to dynamic input conditions by specifying the proportion of new input data to recent average data that is to be used in updating the floating filter "constant".

Default value: 0.0
Allowable range of values:
0 < F < 1

SYSTEM STATUS RECORD

****

Syntax: S

Purpose: Requests that a system status record be transmitted to the host computer.

Relatives: T

****

STATUS

Description: Status refers to the capability to determine information about the system that is not available from other commands.

Commands: S, T

FLOW a scalar value that specifies the maximum allowable filtering to be applied to the outputs during periods of relatively static input conditions.

Default value: 1.0
Allowable range of values:
0 < FLOW < FHIGH

FHIGH a scalar value that specifies the minimum allowable filtering to be applied to the outputs during periods of highly dynamic input conditions.

Default value: 0.0
Allowable range of values:
FLOW < FHIGH < 1

FACTOR a scalar value that specifies the maximum allowable transition rate from minimum filtering (for highly dynamic input conditions) to maximum filtering (for relatively static input conditions) by proportionately limiting the incremental difference between successive filter "constant" updates

whenever the input conditions effect a transition to a narrower bandwidth.

Default value: 0.0
Allowable range of values:
0 < FACTOR < 1

When the form of the command is x0,1,0,0,<> (default), the effect is to disable the position filter. To use this filter, a recommended first trial command is v0.2,0.2,0.8,0.8<> .

Relatives: v

****

ACTIVE STATION STATE

****

Syntax: lstation,[state]<>

Purpose: Set the on/off station state. If the optional parameter is missing, the system returns the current state for the specified station as an output record of type "l". The parameters are:

Station 1 or 2

state 0 = off
1 = on

Relatives: none

****

STATIONS

Description: A station is a transmitter-receiver pair. In an InsideTRAK, the two receivers of a board, paired with the one available transmitter, are assigned station numbers one or two (1-2). Stations may be activated or deactivated. If a station is active, data records are transmitted for that station; otherwise, no data records for that station are transmitted. At least one station in a master board must always be active; any attempt to deactivate a lone station is ignored.

Default: Both stations are assumed active.

Commands: l

SYNCHRONIZATION

Description: Synchronization refers to the command involved in controlling the system synchronization mode. The "y" command provides a means to change system synchronization.

Commands: y

SET SYNCHRONIZATION MODE

****

Syntax: y[smode]<>

Purpose: This command allows the host to set the system synchronization mode. If the optional parameter is omitted the system returns the current value of the synchronization mode as an output record of type "y". The specific parameter is:

smode 0 signifies that the system is internally synced. The next cycle starts after the previous cycle time has expired.

1 signifies that the system is externally synced to another system.

2 signifies that the system is synced via software. See section 7.0 for details.

Relatives: None

****

METRIC CONVERSION UNITS

****

Syntax: u

Purpose: Sets the distance units to centimeters. Subsequent inputs are interpreted as centimeters. Subsequent output command responses are scaled to centimeters. The system default is inches.

Relatives: U

****

SET UNITS INCHES

****

Syntax: U

Purpose: Sets the distance unit to inches. Subsequent input lengths are interpreted as inches. Subsequent output command responses are scaled to inches. System default is inches.

Relatives: u

****

RESET

Description: Reset refers to the capability of changing system control values of the system to an initial start-up state. The following commands provide this means.

Commands: W, ^y

RESET SYSTEM TO DEFAULTS

****

Syntax: W

Purpose: This command resets many system variables to their factory default values without going through the power-ON sequence. However, this is not a complete system refresh like the ^y command. Only variables of commands that specify a particular system default are reset.

Relatives: ^Y

****

COMMAND INPUT/OUTPUT UNITS

Description: Command Input/Output Units is a reference to the distance unit assumed by the system when interpreting input data or when formatting a response to an input command request for data. The current distance unit may be retrieved from the status record. Refer to the S command in this chapter.

Note - these commands have NO effect on output scaling of the system data record generated to report the position, orientation, etc. of any receiver.

Default: Inches

Commands: U, u

DISABLE CONTINUOUS OUTPUT

****

Syntax: c

Purpose: Disable continuous output to the host computer. Default value is non-continuous (i.e., c).

Relatives: C, P

****

REINITIALIZE SYSTEM

****

Syntax: ^Y

Purpose: Reinitializes the entire system to the power up state. The system will run through its initial self test and power-ON sequence of BIT.

Relatives: W

****

ENVELOPE

Description: Envelope refers to the angular and positional limits in which the receiver is allowed to operate. Movement of the receiver outside these limits results in a software bit error. Refer to the explicit commands for the definition of these software bit errors. All coordinates are given in the transmitter reference frame. Refer to Figure 1-2. The units of the position coordinates are interpreted according to the units flag as set by the "U" or "u" command.

Range: The defaults are the maximum envelope allowed.

Commands: Q, V

SINGLE RECORD TRANSMISSION

****

Syntax: P

Purpose: This command requests that a single data record be transmitted to the host host computer. Continuous print mode must be disabled (c). If more than one station is active, one record for each of the active stations will be transmitted in station number order.

Relatives: C, c

****

CONTINUOUS OUTPUT

****

Syntax: C

Purpose: This command enables the continuous output mode for the system. This mode excludes "P" commands and immediate requests via interrupt. Default is non-continuous where data may be requested via "P" commands or immediate requests via interrupt.

Relatives: c, P

****

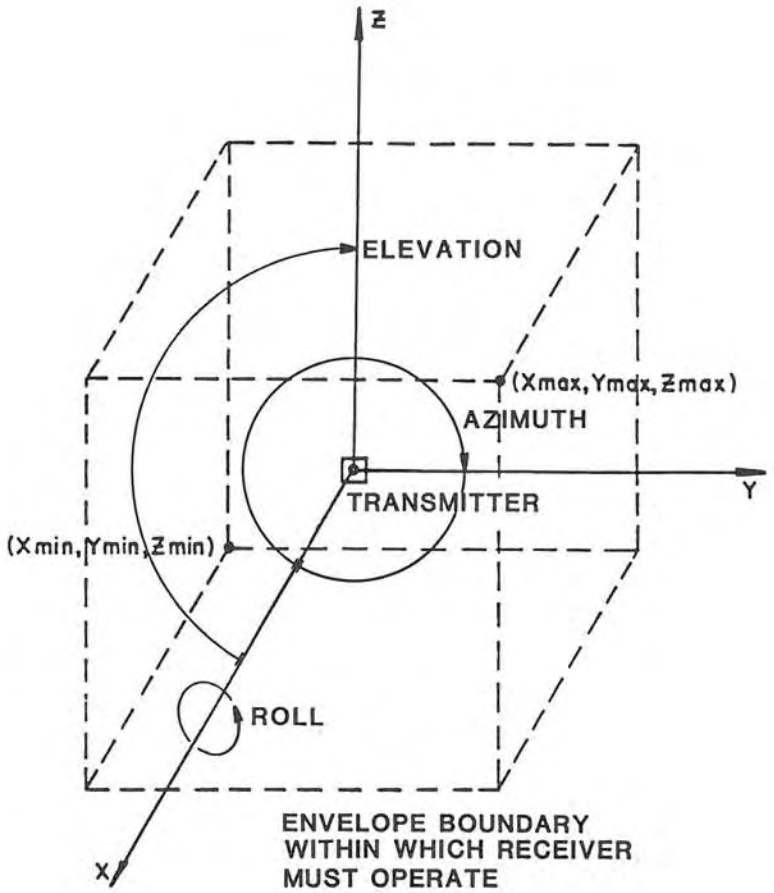

Figure 1-2 System Envelope

ANGULAR OPERATIONAL ENVELOPE

****

Syntax: Qs,[amax],[emax],[rmax],[amin],[emin],[rmin]<>

Purpose: The angular operational envelope is established with this command. This command may be used to impose software angular limits on the system outputs. If the computed system outputs for a given receiver outside of these limits, the output is flagged with a BIT error code "y". If all of the optional parameters are omitted the system returns the current value of the parameters. The specific parameters are:

- s — the number of the station whose angular limits are to be returned or established.
- amax — the maximum azimuth value for the angular operational envelope.
- emax — the maximum elevation value for the angular operational envelope.
- rmax — the maximum roll value for the angular operational envelope.

OUTPUT TRANSMIT MODE

Description: Transmit mode refers to whether the system automatically transmits a data record when it is ready (CONTINUOUS), or the host must request each data record by sending a "P" command or a transmit interrupt to the system (NON-CONTINUOUS). The current transmit mode may be retrieved from the status record.

Default: NON-CONTINUOUS.

Commands: C, P, c

56 y-axis direction cosines (line-of-hear)
57 z-axis direction cosines (line-of-plumb)
58 x-receiver data (factory use only)
59 y-receiver data (factory use only)
60 z-receiver data (factory use only)
61 orientation quaternion
62 self calibration data
63 adjusted x-receiver data (factory use only)
64 adjusted y-receiver data (factory use only)
65 adjusted y-receiver data (factory use only)

****

66-99 not used (reserved for future use)

If all of the optional parameters are omitted, the system returns the current list of selected data items as an output record of type "O".

Relatives: none

Default: On,2,4,1<>; i.e., the three Cartesian coordinates, the three orientation angles, carriage return, and line feed for both stations n=1,2.

****

amin the minimum azimuth value for the angular operational envelope.

emin the minimum elevation value for the angular operational envelope.

rmin the minimum roll value for the angular operational envelope.

If any of the parameters are omitted the current value of that parameter is used. The system default values are:

180, 90, 180, -180, -90, -180

Relatives: V, q

****

POSITION OPERATIONAL ENVELOPE

****

Syntax: Vs,[xmax],[ymax],[zmax],[xmin],[ymin],[zmin]<>

Purpose: The position operational envelope is established with this command. This command may be used to impose software positional limits on the system outputs. If the computed system outputs for a given receiver is outside of these limits, the output is flagged with a BIT error code "s". If all of the optional parameters are omitted the system returns the current value of the parameters. The specific parameters are:

s — the number of the station whose position limits are to be returned or established.

xmax — the maximum x-coordinate for the position operational envelope.

ymax — the maximum y-coordinate for the position operational envelope.

zmax — the maximum z-coordinate for the position operational envelope.

8 x-receiver data (factory use only)
9 y-receiver data (factory use only)
10 z-receiver data (factory use only)
11 orientation quaternion
12 self calibration data (factory use only)
13 adjusted x-receiver data (factory use only)
14 adjusted y-receiver data (factory use only)
15 adjusted y-receiver data (factory use only)

****

16-49 not used (reserved for future use)

32-BIT IEEE Float output in accordance with the format specified by ANSI/IEEE Std 754-1985 Specification for Binary Floating Point Arithmetic. (50-66) (See pages 2-2 and vii.)

50 "NULL" 16-bit word (same as 0)
51 ASCII carriage return, line feed pair (same as 1)
52 x,y,z cartesian coordinates of position
53 not used (reserved for future use)
54 az,el,roll Euler orientation angles
55 x-axis direction cosines (line-of-sight)

OUTPUT DATA LIST

****

Syntax: Ostation,[p1],[p2],...,[pn]<>

Purpose: This command allows the user to define the list of variables to be output to the host computer for the specified station. Any combination of up to 32 data items that total less than or equal 1024 16-bit words is permissible; however, an increased output size will have an impact on system cycle time and system latency. The allowable values of the parameters are:

station 1 or 2

p1...pn
16-BIT Integer (See pages 2-2 and viii.)

0	"NULL" 16-bit word
1	ASCII carriage return, line feed pair
2	x,y,z cartesian coordinates of position
3	not used (reserved for future use)
4	az,el,roll Euler orientation angles
5	x-axis direction cosines (line-of-sight)
6	y-axis direction cosines (line-of-hear)
7	z-axis direction cosines (line-of-plumb)

xmin	the minimum x-coordinate for the position operational envelope.
ymin	the minimum y-coordinate for the position operational envelope.
zmin	the minimum z-coordinate for the position operational envelope.

If any of the parameters are omitted the current value of that parameter is used. The system default values are:

78.74, 78.74, 78.74, -78.74, -78.74, -78.74 in inches or

200.0, 200.0, 200.0, -200.0, -200.0, -200.0 cm.

Relatives: Q

****

HEMISPHERE

Description: Because of the symmetry of the magnetic fields generated by the transmitter, there are two mathematical solutions to each set of receiver data processed. Therefore, only half of the total spatial sphere surrounding the transmitter is practically used at any one time without incurring an ambiguity in X, Y, Z measurements. This half sphere is referred to as the current hemisphere. The chosen hemisphere is defined by an LOS (line-of-sight) vector from the transmitter through a point at the zenith of the hemisphere, and is specified by the LOS direction cosines. Refer to Figure 1-3.

Range: -1 <= # <= +1 for each parameter of th H command.

Commands: H

Default: The transmitter reference frame X-axis defines the default hemisphere.

OUTPUT LIST

Description: The output list refers to the subset of data items to be included in a data record. Any combination of up to 32 data items that total less than or equal 1024 16-bit words is permissible. See the "O" command for a list of data items.

Commands: O

SYSTEM OUTPUT DEFINITION

Description: System output definition is accomplished by several commands. The following command sets affect the various output possibilities:

OUTPUT LIST and
OUTPUT TRANSMIT MODE

With the various commands and their multiple parameters, outputs may be tailored to each user's requirements. The output command sets follow.

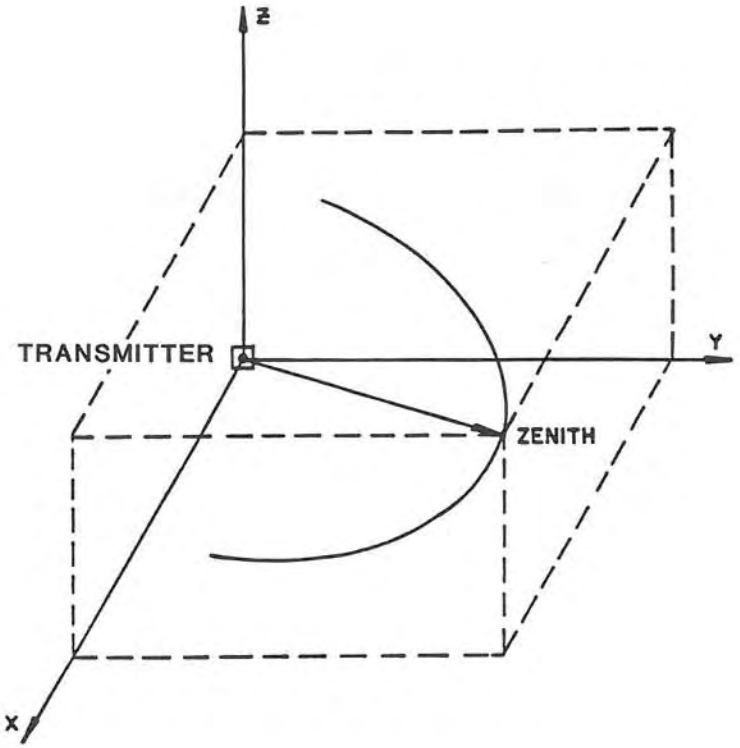

Figure 1-3 System Hemisphere

HEMISPHERE OF OPERATION

****

Syntax: Hstation,[p1],[p2],[p3]<>

Purpose: The operational hemisphere for a particular station is established with this command. The command parameters are:

station	the number of the station whose operational hemisphere is to be adjusted.
p1	the x-component of a vector pointing in the direction of the operational hemisphere.
p2	the y-component of a vector pointing in the direction of the operational hemisphere.
p3	the z-component of a vector pointing in the direction of the operational hemisphere.

If all the optional parameters are omitted the system will return the vector components for the hemisphere of operation for the specified station as an output record of type "H".

The default value is: 1, 0, 0

Relatives: none

****

- Turn continuous output off. [send 'c' to the tracker]
- Wait 32 milliseconds
- Flush the buffer
- To ensure that the second station is also flushed, repeat operations: again turn continuous output off. [send a 'c' to the tracker]
- Wait 32 milliseconds
- Reflush the buffer
- Send a command with output of known length such as 'S' or "A1<>"
- Wait 32 milliseconds
- Examine the data for known data content, and length of the buffer. Be flexible, data lengths can vary due to indeterminate initial state, and possible out of range data elements. Further data content may change with different software revisions. A small range of lengths may be best.

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PROGRAMMER'S

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3SPACE® INSIDETRAK®

USER'S MANUAL

5.6 General Print Request

The usual way to request data from the tracker is to send an ASCII 'P' or 'C' request then process data. The data request will be honored starting with station 'A' followed by 'B', of course depending on which stations are selected. Stale data will result if the FIFO buffers are not continuously flushed. This applies also if the instant data request is sent by the procedure in 5.5. A code segment to do this task is:

```
put_data(bus_address, "P", 1);     // one set of records
```

or

```
put_data(bus_address, "C", 1);     // continuous set of records
```

6.0 NO DEVICE OR WRONG DEVICE ON BUS

Depending on the PC bus, the state of the status words on the bus may float high or low at the assumed address of the INSIDETRAK interface card. For this reason it is necessary to use a combination of counting data read on the bus, and to limit the number of words read from the 512 word FIFO.

To determine the state of the interface, it is suggested that the following procedure be used:

5.4 Synchronization

The user should have previously sent a command "y2<>" to place the INSIDETRAK in software sync[hronized] state. The routine outlined sends a software sync pulse to the INSIDETRAK. Refer to section 7, page 25, of the main section of the manual.

```
#include <dos.h>

void    send_sync(bus_address)   {    outportb(bus_address, 0x4);}
```

5.5 Instant Data Request

The fragment that follows sends a data request to the station specified. The station number is 1-based, rather than 0 based. Error control may be expanded to meet individual needs.

```
#include <dos.h>

void    send_data_request(bus_address, station_no)
{
switch(station_no)
   {
   case 1:        // station A, assumes 1-based station numbering
   case 2:        // station B
        outportb(bus_address | 1, station_no);
   default:                    // error control is no action
        break;
   }
return;
}
```


TABLE OF CONTENTS

```
#include <conio.h>
#include <stdio.h>
#include <dos.h>

void    put_data(unsigned bus_address, char *cbuf, int nc)
{
int i, ib;

for(i=0;i<nc;i++)
    {
    ib=inp(bus_address|1);
    if( (ib&2) == 0)    /* tst for ful == bit 1 */
        {
        gotoxy(40,1);  printf("Reading FULLDATA on the bus.");
        delay
        }
    outportb(bus_address, cbuf[i]);
    }
}
```

5.3 Get Status

This routine may be coded as an inline routine, assuming your compiler has this feature. When bit zero of the received status is zero, the incoming FIFO is empty. When bit one of the status is zero, this indicates that sending data to the outgoing FIFO is a NOGO. Other bits are reserved for future use and unspecified.

```
#include <conio.h>

unsigned get_status(bus_address)
{
return (unsigned)inp(bus_address | 1);
}
```

```
#include <conio.h>

int  get_data(unsigned bus_address, int *buf)
{
int i;
char bsts;

bsts = inp(bus_address|1)&1;     // status of ncoming data
for (i+0; (bsts &1)&& i < 512;
          bsts = inp(bus_address|1)&1,i++) '' data available = = bit
0
    buf[i] = inpw(bus_address);
return i;                                // count of words read
}
```

5.2 Write Data

This routine writes the array to the port specified in the count argument. The bus address is assumed to have been validated. No status or error information is output.

PURPOSE

This document is intended as a source for those writing a program interface, a TSR, or a driver for DOS, Windows, Linux, or PC-UNIX. Additional details for a TSR or a driver are found in standard reference texts. The user of this document should be familiar with these details when writing an interface program for the PC, and also with the above referenced operating systems.

0.0 GENERAL

The user is referred to other details of programming the PC interface in the TRAK program source code and sections 5 to 7 of the INSIDETRAK manual, pages 11, and 19-25.

0.1 Viewpoint

Perspective of this document is from the PC interface.

0.2 Prior Manual Errata

Material in this manual supersedes information in Appendix B of the INSIDETRAK manual, including: Un-numbered table on page B-24 and table 2 on page B-25 being replaced by table D-1 and table D-2 respectively.

1.0 BUS ADDRESSES

Upon selecting a non-interfering bus address[reference OPM3792-001 sections 5.4, 6.0], this address and the next 3 provide access to the Insidetrak device. Data transfer, status, immediate station requests, and software sync are effected through these registers. Table 2 of appendix B indicates the bit configuration. The default bus address is hexadecimal 300 or decimal 768.

Table D-1. Synchronization Actions

Port Signal Actions	INSIDETRAK Command Sequence
Send command to turn s/w sync off y0< >	Type F1 for data capture Type y0< >
Send dummy data to base port + 3	Type F3
Test the effectiveness by requesting data from the port. Transmit 'P' to the base port; request status or static data.	Test the effectiveness by requesting data from the port. Transmit 'P' to the base port; request status or static data.

commands is already in ASCII and scaled to the correct linear units. Units can be set by use of the 'U' and 'u' commands, and extracted by examining the output of the 'S' command. The TRAK program has chosen to copy the units status when sending data to the Insidetrak.

4.2 Print Format

The O command information may be maintained by defaults of the INSIDETRAK: Ox,2,4,1, that is for station x, format is position as a scaled integer, followed by Euler angles, followed by a CR and a LF.

One may either keep track Format commands sent to the INSIDETRAK or query the tracker with a "O1<>" and "O2<>" request.

5.0 CODE FRAGMENTS

This section contains a number of code fragments in C.

5.1 Get Data

This routine obtains a record off the bus, placing it in the array whose pointer is specified. The number of bytes read is returned to the caller.

3.0 UNITS IN SCALED INTEGER

Data formats may be selected by the use of the [capital] "O" command. The number of fields, the size of the individual fields and the meanings of each are specified on pages A48 through A51 of the INSIDETRAK manual.

Data for formats 2 and 4 are scaled integers. Scale for data transmitted via format 2 is maximum positive range of 0x7fff[32767] representing 299.99 cm. Scale for format 4, Euler angles, is 32767 represents 179.995 deg.

4.0 COORDINATE DATA

The state of two data items must be maintained jointly in the embedded processor and the interface program. These items are the linear units, determined by the 'U' and 'u' commands, and the format information of the capital 'O' command. Position is always centimeters from the INSIDETRAK, while static data requests, from commands such as A1, V1, and V3 are generated in the current units.

4.1 Units for Floating Point

Data written from the INSIDETRAK in IEEE 32 bit floating point binary is centimeters for format 52, and degrees for format 54.

The interface maintains the units status. Units for output other than the 'P' and 'C'

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Table D-2. I/O Board Control Bit Definition

Bus Addr Offset	Input/Output Functionality	Data Bit	Source
+0	8 bit data transfer Transmit	none spec	PC
+0	16 bit data transfer Receive	none spec	IT
+1	Status of data to PC	bit 0=1 is IT data on FIFO	IT
+1	Status of data sent to INSIDETRAK	Bit 1=0 is full FIFO to Tracker	IT
+1	Request immediate data stn 1/A	Send dummy 0	PC
+2	Request immediate data stn 2/B	Send dummy 0	PC
+3	Send software synch. pulse	Send dummy 0	PC

1.1 Data In

Data are received over the base address for the Tracker board. It is essential that the data be read as a word fetch, so the hardware FIFO remains synchronized on both bytes.

1.2 Data Out

Data out is sent over the base address of the port. The data path is one byte wide.

1.3 Bus Status

Status and other bus functionality is at base address +1. The low bit of the received

status is specified as 0 indicating an empty receiving FIFO and 1 indicating data output is available to be read. Bit 1 indicates that the outgoing [from the PC perspective] FIFO is full when 0, and otherwise 1 indicates space available.

1.4 Write Software Sync

To write a software sync pulse to the INSIDETRAK output, first send a software sync mode command [y2<>] to the INSIDETRAK, and then send a dummy byte to base address +3.

1.5 Request Data

Two immediate data request commands can be sent. These assure that data output does not become stale from lack of previous interface program action. Sensor 1 [A] uses the port at base address +1. Sensor B uses the port at base address +2. Be sure that the station requested is active, that both stations are not simultaneously requested, and that the data output for one station is taken off the FIFO before the second request is issued. Refer to sections 5.6 and 6.1 of main manual for additional discussion.

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1.6 ASCII Print Request Command

The common practice is to send an ASCII 'P' over the data port to the INSIDETRAK. Refer also to title 1.2, Data Out.

1.7 Interrupt Routine

Data may be received in interrupt mode. The writer must be familiar with processing this type of program and redesign the main logic to monitor a flag indicating data in a buffer, rather than the status of the FIFO flag on the bus. Considerations are that the interrupt routine must require no more than 54 milliseconds, as the timer interrupt would miss an update, and the clock would mis-register. Interrupts also must not conflict with existing interrupts and IRQ levels. There are means of polling the appropriate status and ports to determine the source of interrupts to resolve conflicts that arise. Refer to sections 5.6 and 6.1 for additional discussion of enabling interrupts, setting the IRQ level, and special modes.

2.0 COMMANDS

Commands are transmitted as single bytes or a string of hex 0xD or 0xA terminated bytes using the port described in 1.2, Data Out.