pcBIRD™

POSITION AND ORIENTATION MEASUREMENT SYSTEM

INSTALLATION AND OPERATION GUIDE

910009-A Rev A
March 30, 2000

PO Box 527
Burlington, Vermont 05402 USA
(802) 893-6657

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FCC Regulations

Warning: Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at the user’s expense.

Canadian Regulations

This digital apparatus does not exceed the Class A limits for radio noise emissions from digital apparatus set out in the Radio Interference Regulation of the Canadian Department of Communications.

Le present appareil numerique n'emet pas de bruits radioelectriques depassant les limites applicables aux appareils numeriques de la class A prescrites dans le Reglement sur le brouillage radioelectrique edicte par le ministere des Communications du Canada.

EC Declaration of Conformity
Issued by

Ascension Technology Corporation
PO Box 527
Burlington, VT 05402 USA
802-893-6657

Equipment Description: pcBIRD Model
pcBIRD Tracking System
5V @ 4.5A, 12V @ 1.5A
No -5V or -12V

Tested With: The pcBIRD passed all CE directives when using a P75 Gateway computer S.N. 3883077

Year of Manufacture: 2000

Applicable Directives: 73/23/EEC, Low Voltage Directive
89/336/EEC, EMC Directive

Applicable Standards: EN 61010-1: 1993
Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use, General Requirements

EN 50081-1: 1992
Electromagnetic Compatibility - Generic Emission Standard, Residential, Commercial and Light Industry

EN 50082-1: 1997
Electromagnetic Compatibility - Generic Immunity Standard, Residential, Commercial and Light Industry

Authorized by: _____ **Date:** _____
Ernie Blood
President
Ascension Technology Corporation

CE Specifications

There are no fuse or user serviceable parts on the pcBIRD.

Modification or use of the equipment in any way that is not specified by Ascension Technology may impair the protection and accuracy provided by the equipment.

The lightning flash arrow symbol within an equilateral triangle is intended to alert the user to the presence of uninsulated “dangerous voltage” within the product’s enclosure. That voltage may constitute a risk of electric shock to persons.

The exclamation point within an equilateral triangle is intended to alert the user to important operating and maintenance (servicing) instructions in the appliance literature.

Equipment Maintenance:

1. Do not block the ventilation holes on the PC’s casing.

2. Do not expose the pcBIRD to rain or condensing moisture.

3. Keep the equipment away from extreme sources of heat.

TABLE OF CONTENTS

USER MANUAL REVISIONS

Manual Date	Rev	Changes
February 23, 1996		Initial release for standalone ISA bus version with rev 6.03 PROM memory.
March 12, 1996		Miscellaneous typographical corrections.
May 30, 1996		Jumper assignments for TTL or CRT SYNC inputs are now correct. Tests 21 and 23 added to test or not test for receiver present starting with rev 6.04 PROMS.
June 28, 1996		FBB ADDRESS command description added. Command is present in all previous PROMS.
March 30, 2000	A	Added the FBB Reset command. Added the following Change/Examine commands: Addressing Mode, Line Frequency, FBB Address, Hemisphere, Angle Align2, Reference Frame2, Serial Number. You need to have at least EPROM software rev 3.67 for these new commands. Changed the word receivers to sensors. Added how to change the position/angles from Hex to inches/degrees. Added the pcBIRD specifications section. Added additional error messages for the optional ERC/ERT. Added the RS232 chapters for communication with the optional ERC/ERT. Added the Sensor Serial Number and Transmitter Serial Number commands. You need to have at least EPROM software rev 3.71 for these new commands.

1.0 INTRODUCTION

The pcBIRD is a six degrees-of-freedom measuring device that measures the position and orientation of a small body-mounted sensor when located within ± 4 feet of its transmitter. When used with the optional Extended Range Transmitter and Extended Range Controller, the pcBIRD can operate over a distance of ± 10 feet. The pcBIRD determines position and orientation by transmitting a pulsed DC magnetic field measured by the sensor. From the measured magnetic field characteristics, the sensor electronics card computes its position and orientation and makes this information available to you over your host computer's ISA bus.

The pcBIRD consists of a single electronics card that is compatible with PC's and other computers with an ISA bus slot. A single transmitter and sensor plug into the pcBIRD circuit card. Multiple pcBIRD cards can be run in the same PC chassis if multiple sensor operation from a single transmitter is required. In this configuration, the pcBIRD cards are tied together with an internal bus cable to synchronize their operation. Because each card has its own independent computer, the measurement rate is not reduced as sensors are added to the configuration.

In addition to this manual, the user can now receive on-line assistance at Ascension's web site:

http://www.ascension-tech.com/support/troubleshoot/index.htm

1.1 PRODUCT ADVISORY

Ascension sensors and transmitters – along with their attached cables/connectors – are sensitive electronic components. To obtain good tracking performance and maintain your warranty, treat them carefully.

Most failures in the field occur because the cables attached to the sensors and transmitters are mishandled. Always remember that these components are not designed to withstand sever jolting, contortions, or high-impact shocks. When handling your cables please observe the following:

- **Never flex, pull or twist cables.** This is the most common cause of tracker failure. Note that there is a strain relief where the sensor head attaches to its cable. Its job is to protect the delicate connection between the cable conductors and the sensor assemble head. It is also the are in which sensors are attached to the object that is being tracked. When attaching the sensor to the object that is to be tracked, be sure that you do not pull, twist or repeatedly bend the cable here. Consider adding a secondary strain relief if the cable is prone to contortions.

- **Never yank the sensor off its mounting bracket or holder by grabbing the cable and pulling.**

- **Never carry, throw or swing a sensor by its cable.**

- **Never let the sensor impact with a hard object.**

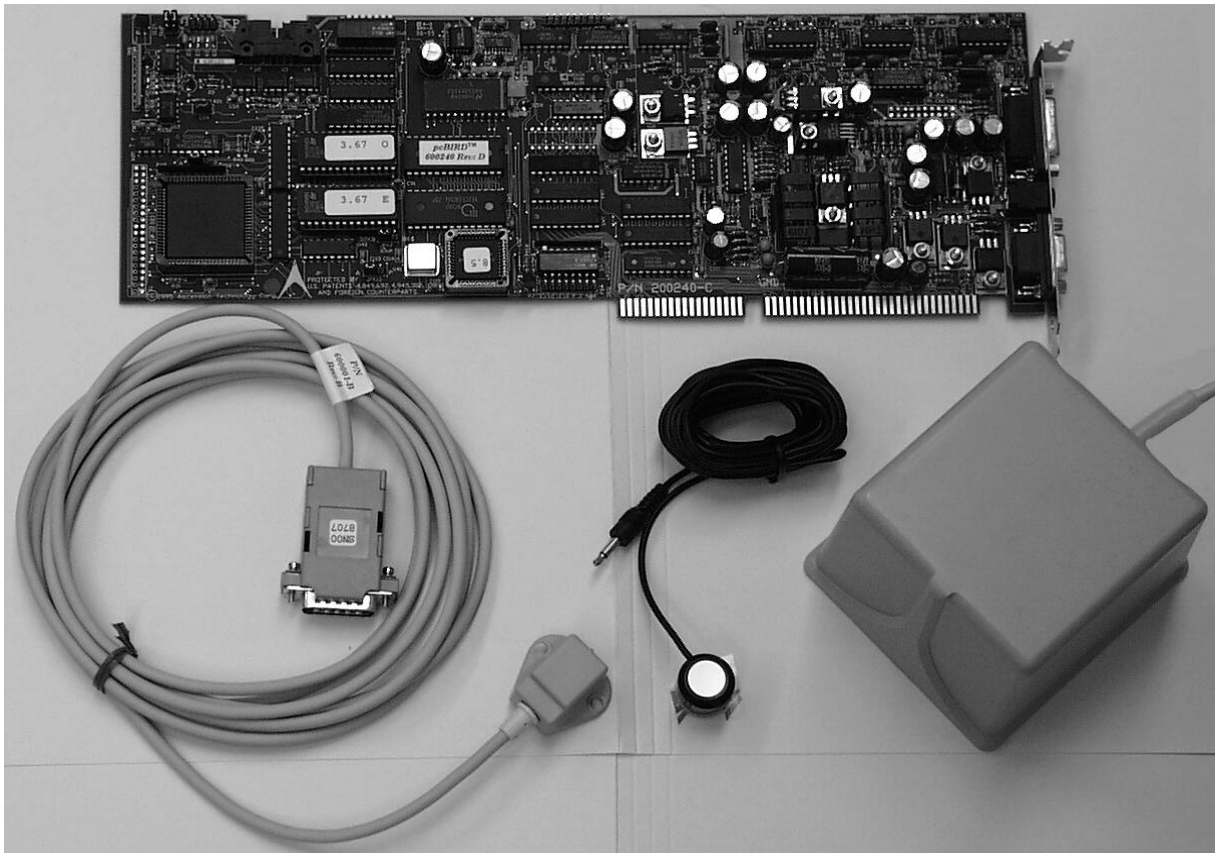
- **Never add your own extensions/connectors** to our sensor/transmitter cables without our pre-approval. Our cables are precisely bundled and shielded to minimize noise and ensure accurate performance within specification. If you add an extension without our knowledge or approval, you may compromise the performance and/or negate certain regulatory certifications. You will also void your warranty. If you need to extend your cable lengths, please contact our tech support team first:

Phone: 1-802-893-6657
Fax: 1-802-893-6659
Email: techsupport@ascension-tech.com

2.0 INSTALLATION

The pcBIRD is shipped to you in one box containing the following:

- One electronics unit
- One transmitter
- One sensor
- One CRT SYNC cable
- One 3 ½ inch DOS-formatted diskette of user software
- A package of spare jumpers for the pcBIRD circuit card
- One Installation and Operation Guide
- If you are using multiple pcBIRD cards in a Master/Slave configuration then one of the pcBIRD boxes will also contain a multi-unit FBB bus cable



If there are any discrepancies or your shipment is damaged, call Ascension Technology at (802) 893-6657 between the hours of 9 AM and 5 PM Eastern Standard Time or fax us at (802) 893-6659.

2.1 COMPONENT LOCATION

2.1.1 STANDARD RANGE TRANSMITTER LOCATION. The transmitter should be mounted on a non-metallic surface such as wood or plastic, using non-metallic bolts or 300 series stainless steel bolts. If you are going to mount the transmitter upside down, note that the two mounting holes are not strong enough to support the weight of the transmitter. Instead, you should use hardware or grooves to capture the flanges along both sides of the transmitter in addition to bolting through the two mounting holes. Do not mount the transmitter on the floor (concrete included), ceiling or walls because these all contain metal or may have large metal objects directly on their opposite side.

Because the transmitter generates magnetic fields, it may interfere with your computer's display, causing image bending, jitter or color distortion. With an unshielded commercial CRT-type display, the transmitter usually must be at least 12 inches away. With a shielded CRT, the transmitter can be closer.

2.1.2 SENSOR LOCATION. The sensor should also be mounted on a non-metallic surface such as wood or plastic, using non-metallic bolts or 300 series stainless steel bolts. It should not be located near power cords, power supplies or other low frequency current generating devices. Their emanations will be picked up by the sensor and converted into noise on the output position and orientation measurements. The sensor will pick up noise when it is operated near a CRT-type display. The amount of noise will vary depending on the operating frequency of the CRT and the amount of shielding built into the CRT. If you are going to use the sensor within a few feet of a CRT, then use the CRT SYNC command in conjunction with the CRT synchronization pickup cable provided with your unit to minimize noise picked up from the CRT.

2.2 SYSTEM ELECTRONICS CARD

2.2.1 CONFIGURING THE CARD. Before you install the pcBIRD card in your chassis, configure the pcBIRD card. To configure the card you must do the following:

1. Set the ISA bus Base Address dip switch
2. Set the IRQ number jumper block
3. Set board jumpers 1 - 14
4. Set the configuration dip switch

Appendix III contains a list of all jumpers in the electronics unit. To locate the jumpers, refer to the printed circuit card drawings in Appendix IV. The jumper blocks can be removed and inserted vertically with a strong set of fingers.

W A R N I N G

The system electronics card contains static electricity sensitive components that may be damaged if you touch the card. As a precaution, always touch the metal chassis of the PC before touching any part of the card.

W A R N I N G

NEVER install or remove the electronics card when the PC's power is ON. The card and the PC may be damaged.

2.2.1.1 BASE I/O ADDRESS. The Base Address dip switch selects the ISA bus I/O address for sending and receiving data from the pcBIRD. This dip switch allows the user to select Base Addresses from 000 Hex to 3FC Hex in address steps of 4. The pcBIRD uses Base Address+0 and Base Address+2. In selecting a Base Address for the pcBIRD, you must have no other devices on the ISA bus that use Base Address+0, +1, +2 and +3. The system is shipped with a Base Address of 200 Hex. If your shipment also includes slave cards, they have addresses 204, 208, etc.

Dip switch pins 7 and 8 determine the one hundred range (i.e. 100, 200, 300) and pins 1 through 6 determine the one and tens range (i.e. 00, 04, 08, 70, etc.).

Example Base Address settings are as follows:

dip switch number	8	7	6	5	4	3	2	1	Base Address
	0	1	0	1	1	1	0	0	170 Hex
	1	0	0	0	0	0	0	0	200 Hex
	1	0	0	0	0	0	0	1	204 Hex
	1	0	0	0	0	0	1	0	208 Hex
	1	1	0	0	0	0	0	1	304 Hex

Here, the two least significant bits to the right of the number one dip switch are fixed at zero and the two most significant bits to the left of the number eight switch are zeros.

On the Base Address dip switch, 0 = switch down = toward the PC card, and 1 = switch up = away from the PC card = the OFF label on the switch.

If you cannot talk to the pcBIRD, it may be because the I/O address you have selected is the same address used by another device in your system. Try another address. In a PC, the I/O address space is usually assigned per the following table. Use this to help select a non-interfering address.

I/O Address Range	Device
1F0 - 1F8	Fixed disk
200 - 207	Game port
278 - 27F	LPT2
2E8 - 2EF	COM4
2F8 - 2FF	COM2
300 - 31F	unused or network
360 - 363	PC network low address
368 - 36B	PC network high address
378 - 3F7	LPT1
380 - 38F	SDLC, bisynchronous
3A0 - 3AF	Bisynchronous primary
3B0 - 3BF	Mono display and printer adapter
3C0 - 3CF	EGA/VGA display
3D0 - 3DF	CGA/MCGA display
3E8 - 3EF	COM3
3F0 - 3F7	Diskette
3F8 - 3FF	COM1

2.2.1.2 IRQ JUMPERS. If interrupt-driven ISA bus operation is required instead of polled operation, you must select which interrupt number is assigned to the pcBIRD card. The pcBIRD can utilize interrupt numbers 3, 4, 5, 9, 10, 11, 12, and 15. Place a jumper plug vertically over the two pins below the interrupt number on the circuit board. If the card is not interrupt-driven, remove any jumpers present. If you are using several pcBIRD cards in the same chassis, all interrupt-driven, each card must use a different IRQ. The cards are shipped with no IRQ jumpers installed.

If you cannot talk to the pcBIRD, it may be because the IRQ number you have selected is used by another device in your system. Try another IRQ. In a PC the IRQs are usually assigned per the following table. Use this to help select a non-interfering IRQ.

IRQ	DEVICE
3	COM2, COM4
4	COM1, COM3
5	LPT2
7	LPT1

2.2.1.3 BOARD JUMPERS. There are 9 jumpers on the circuit board. For most applications, the jumpers should not have to be changed from the default settings. Verify that the jumpers on your board are per Appendix III. If you need to change jumpers, you should only change jumpers 1, 2, and 3.

If using the CRT sync cable supplied with the system, set jumper pins 1 and 2 together on jumpers 1 and 2. If using a user supplied TTL SYNC signal, set jumper pins 2 and 3 together on jumpers 1 and 2. If you are not using any type of SYNC cable, jumpers 1 and 2 can be left in any position or removed. See Section 10.0 SYNC command for operation and Application Note #3 in the Appendix if suppling your own SYNC signal.

2.2.1.4 ADDRESSING MODE CONFIGURATION. The pcBIRD can be operated in three addressing modes: 1) Normal Addressing mode, 2) Expanded Addressing mode, and 3) Super-Expanded Addressing mode.

Normal Addressing mode is used when you have up to 14 BIRD units in your Flock. This mode is the default mode set at the factory. Normal Addressing mode may be permanently changed or set by setting the dip switches to test number #29 (see Section 9.0 for details).

Expanded Addressing mode is used when you have more than 14 BIRD units in your Flock. In this mode, all transmitters must be at addresses 1 to 14 and the sensors are at addresses 1 to 30. In Expanded Address mode, the sensors must be further than 10 inches from the transmitter for the position/orientation information to be correct (or 22 inches for an Extended Range Transmitter). If the sensor is closer than this limit, position and orientation outputs will be zeroed. For example, in MATRIX output mode, all nine output words would be zero. Expanded Addressing mode may be permanently changed or set by setting the dip switches to test number #27 (see Section 9.0 for details).

Super-Expanded Addressing mode is used when you have more than 30 BIRD units in your Flock. In this mode all transmitters must be at addresses 1 to 14 and the sensors are at addresses 1 to 126. In Super-Expanded Address mode. the sensors must be further than 10 inches from the transmitter for the position/orientation information to be correct (or 22 inches for an Extended Range Transmitter). If the sensor is closer than this limit, position and orientation outputs will be zeroed. Super-Expanded Addressing mode may be permanently changed or set by setting the dip switches to test number #31 (see Section 9.0 for details).

2.2.1.5 DIP SWITCH CONFIGURATION. On the top of each pcBIRD unit there is a dip switch that must be set to select the baud rate, unit address and other functions. Whenever you change the dip switch settings, you must reset the pcBIRD's power for the new settings to be recognized by the system. The switch assignments are as follows in Figure 1 for Normal Addressing mode and Figure 2 for Expanded Addressing mode. Super-Expanded Addressing mode only has the one default baud rate of 115.2K.

Dip Switch 8

For the pcBIRD to be in an operational mode (FLY), where it can output position and orientation, dip switch 8 must be set to OFF. When dip switch 8 is set to ON, the system enters TEST mode where it performs the functions specified by the test number set in switches 4, 5, 6, 7. Refer to Section 9.0 for details on each test.

Dip Switches 4, 5, 6, 7 - Normal Addressing Mode (default)

When in Normal Address mode (up to 14 BIRD units on the FBB), each BIRD unit on the FBB is assigned a unique address via dip switches 4, 5, 6, 7. For example, the first pcBIRD might have its address dip switch set to 1 = 0001 = off, off, off, on. The second pcBIRD would then have its addresses set to 2 = 0010 = off, off, on, off. The addresses do not have to be in order, but you cannot skip an address, no addresses can be set to zero, there can be no repeat addresses, and there can be no address = 15 (the Broadcast Address).

Dip Switches 3, 4, 5, 6, 7 - Expanded Addressing Mode

When in Expanded Address mode (up to 30 BIRD units on the FBB), each BIRD unit on the FBB is assigned a unique address via switches 3, 4, 5, 6, 7. For example, the first pcBIRD might have its address dip switch set to 1 = 00001 = off, off, off, off, on. The second pcBIRD would then have its addresses set to 2 = 00010 = off, off, off, on, off. The addresses do not have to be in order, but you cannot skip an address, no addresses can be set to zero, there can be no repeat addresses, and there can be no address = 31 (the Broadcast Address). All transmitter and/or ERT addresses must be located at addresses 1 to 14.

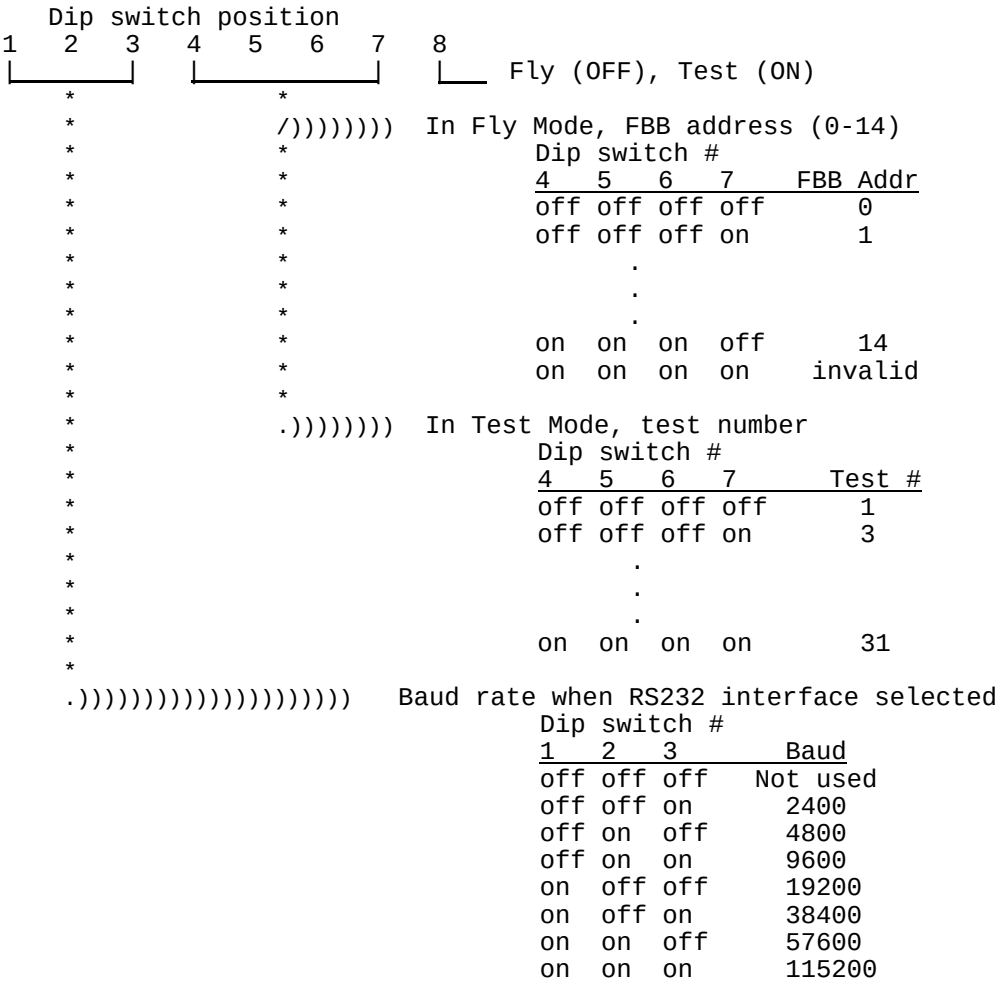
Dip switches 1, 2, 3, 4, 5, 6, 7 - Super-Expanded Addressing Mode

When in Super-Expanded Address mode (up to 126 BIRD units on the FBB), each BIRD unit on the FBB is assigned a unique address via switches 1, 2, 3, 4, 5, 6, 7. For example, the first pcBIRD might have its address dip switch set to 1 = 1000000 = on, off, off, off, off, off, off. The second pcBIRD would then have its addresses set to 2 = 0100000 = off, on, off, off, off, off, off. The addresses do not have to be in order, but you cannot skip an address, no addresses can be set to zero, there can be no repeat addresses, and there can be no address = 127 (the Broadcast Address). All transmitter and/or ERT addresses must be located at addresses 1 to 14.

Dip switches 1, 2, 3 - Normal Address mode (default) baud rate
Dip switches 1, 2 - Expanded Address mode baud rate

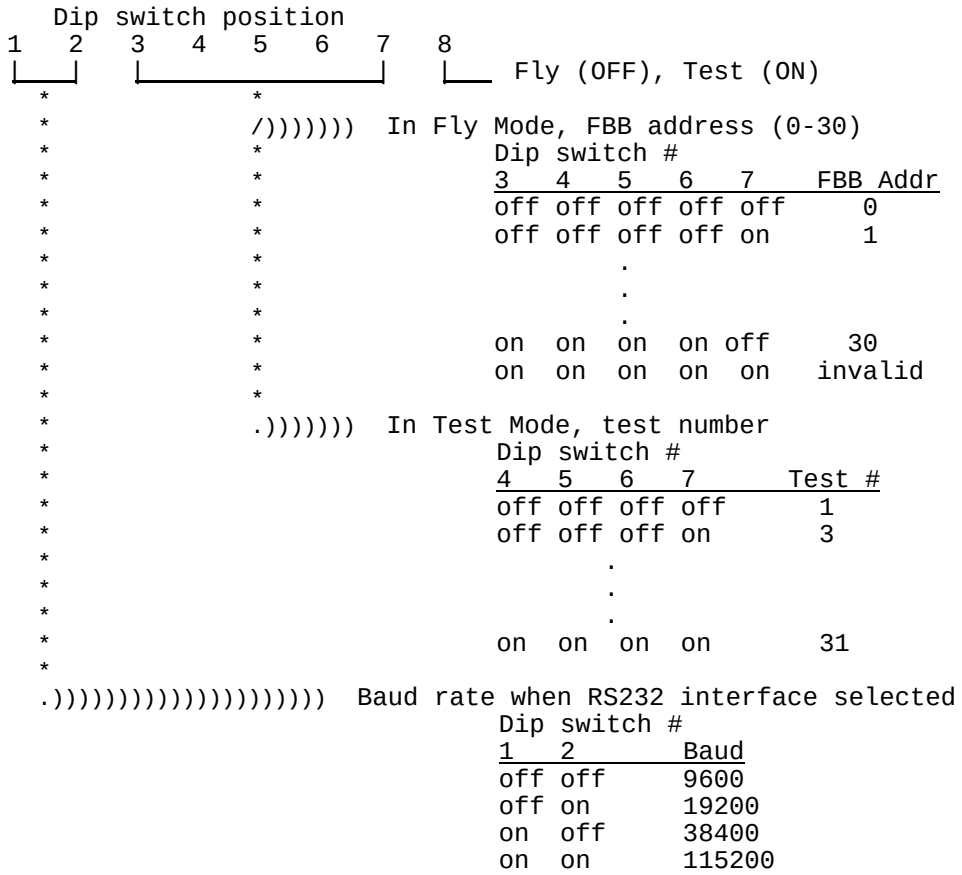
These switches select the desired baud rate.

Note: The Super-Expanded Address mode has only one baud rate of 115.2K.



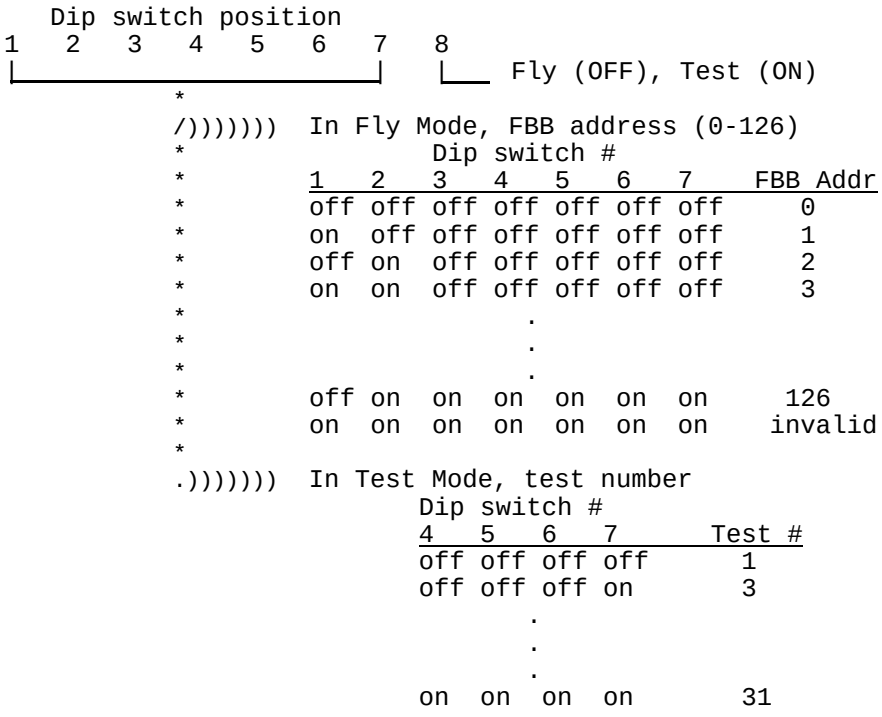
DIP SETTING: OFF = switch UP
ON = switch DOWN

Figure 1. Dip Switch Settings - Normal Address Mode



DIP SETTING: OFF = switch UP
ON = switch DOWN

Figure 2. Dip Switch Settings - Expanded Address Mode



Note: The addresses run backwards from Normal or Expanded Addressing modes (i.e. for Normal and Expanded Addressing modes address = 1 would have pin 7 down, but for Super-Expanded Addressing mode pin 1 is down).

Note: There are no Baud rate dip switches. Baud rate defaults to 115.2K for RS232.

DIP SETTING: OFF = switch UP
ON = switch DOWN

Figure 3. Dip Switch Settings - Super-Expanded Address Mode

2.2.2 INSTALLING THE CARD. Once the switches and jumpers are set, the card is installed into a 16 bit ISA slot connector in your computer (Figure 4) by doing the following:

- Shut the computer's power off.
- Remove the computer's case.
- Remove the slot cover plate from the location where you want to install the pcBIRD card.
- Hold the pcBIRD card along the top edges and insert it vertically into the 16 bit ISA connector in your computer.
- Wiggle the card slightly while maintaining pressure on it until it 'seats' into the connector.
- Screw in the pcBIRD card using the screw removed from the slot cover plate in Step 3.
- Install the computer's case. You may not want to screw in the case until you have verified that the pcBIRD is working. There is a red light(LED) at the top rear edge of the pcBIRD card that is useful to view during initial hardware/software installation. The LED turns on when running and blinks when there is an error (see Section 6.3 for LED details).
- Plug the pcBIRD's sensor cable into the top 15 pin D connector on the card edge shown in Appendix IV. Screw in this connector.
- Plug the pcBIRD's transmitter cable into the bottom 9 pin D connector on the card edge. Screw in this connector.

- CRT sync cable. If you are going to use the sensor within a few feet of a magnetically deflected CRT display (a normal picture tube-type raster-scan monitor), you may need the CRT sync cable to reduce CRT noise picked up by the pcBIRD's sensor. The CRT sync cable contains a CRT sync pickup housing with a velcro pad for attachment to the outside of your CRT. The end of the cable is plugged into the center circular connector located between the transmitter and sensor connecters. For proper operation, it is vital that the sync pickup be correctly positioned on the CRT's housing. Follow the instructions in Section 10.0 for the SYNC command to properly position the pickup. Peel the protective paper from the tape on the velcro attachment and fasten the pickup to the CRT's housing at the predetermined location.

  Note: once you have enabled the CRT sync by setting the SYNC command equal to either CRTSYNCtype 1 or 2, the pcBIRD will stop running if the pickup falls off the CRT.

- If you have a Master/Slave configuration, plug all pcBIRD cards into the chassis. The cards must be in adjacent slots.

- Attach sensor cables to each of these additional cards.

- Attach the multi-unit FBB cable to the multi-unit sync connector on the top of each card.

Power can then be turned on and commands sent to the pcBIRD cards.

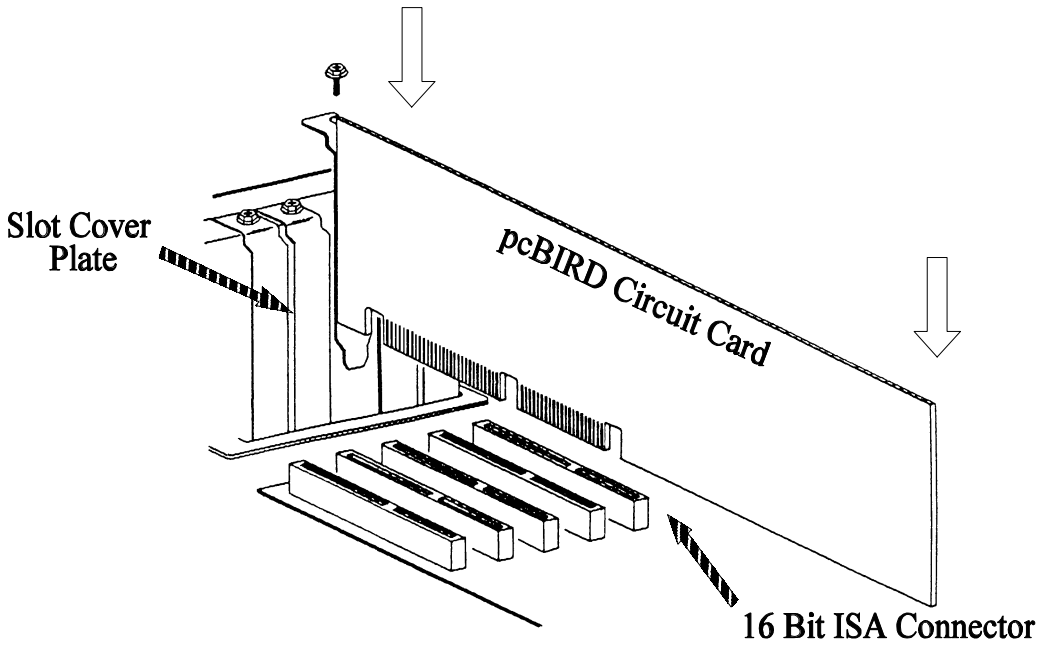


Figure 4. Installation In ISA Slot

2.3 EXTENDED RANGE CONTROLLER/TRANSMITTER OPTION

If you did not purchase the Extended Range Transmitter option, then you do not need to read this section. The pcBIRD with the Extended Range Controller (ERC) and Extended Range Transmitter (ERT) option is a six degree of freedom measuring device that can be configured to simultaneously track the position and orientation of up to 125 sensors with up to four ERTs when using a single ERC. Each sensor is capable of making from 10 to 144 measurements/second of its position and orientation when the sensor is located within ± 10 feet of the ERT.

The ERT option has been designed for simplicity of use and versatility. One ERT mounted on a pedestal in the center of a room generates sufficient signal to allow a user, equipped with one or more motion-tracking sensors to walk about a 16 x 16 foot room. With four ERTs in an array, he or she can walk about a 24 x 24 foot room. No matter how many ERTs are included in a configuration, the Flock will continue to maintain its high measurement rate.

2.3.1 EXTENDED RANGE TRANSMITTER LOCATION.

The most critical item in installing an ERT is selecting a location for placement of the transmitter. A poor location will result in degraded measurement accuracy by the pcBIRD.

When large metal objects are near the transmitter and sensor(s), they will affect the accuracy of the position and angle measurements. A large metal object is considered to be near when the distance from the transmitter to sensor is the same as the distance from the transmitter or sensor to the large metal object. Large metal objects include metal desks, bookcases, files, and the floor, ceiling and walls. In non-wood commercial buildings, the floor and possibly the ceiling are constructed of concrete that contains a mesh of reinforcing steel bars. Walls might be constructed of cinder blocks or plaster board. Plaster board walls, however, usually have internal steel supports spaced every sixteen inches. Even if the wall has no metal in it there may be a large metal object directly on the other side, such as someone's desk. Usually the largest source of error is due to the floor. If you are going to use the sensors at a distance of eight feet from the ERT then the ERT and sensors should be eight feet away from the floor, ceiling, walls or other large metal objects.

The only way to evaluate the building effects is to install the ERT and determine if the accuracy is satisfactory for your application. You can evaluate the accuracy degradation simply by taping one sensor to a cardboard box or yard stick or some other method of holding the sensor at a fixed distance above the floor. As you move the sensor farther away from the ERT in the X direction, record the sensor's Z position output. If the floor is not causing a large error, the Z position output will remain relatively constant as you move away from the transmitter.

The ideal location for the ERT is in an all wood building or in a large room with a stage above the floor for mounting the transmitter and using the sensors.

Because the ERT generates magnetic fields, it may interfere with your computer's display, causing image bending, jitter or color distortion. With an unshielded commercial CRT-type display, the ERT usually must be located at least four feet away.

2.3.2 TRANSMITTER INSTALLATION. Usually the ERT is mounted on a 3 or 4 foot high wood pedestal in the center of the motion capture space or mounted overhead or under the floor of a wood stage. Because the transmitter is very heavy (50 lbs), fragile and subject to performance degradation by nearby metal, the method you use to support the transmitter must be strong and non-metallic. Small amounts of metal in the mount such as steel bolts are acceptable. Supporting the transmitter on a steel or aluminum framework is not acceptable. We recommend wood, structural fiberglass, or laminated phenolic for mounting materials. Two bolt holes in the bottom of the transmitter have been provided for maintaining the alignment of the transmitter to your support. These bolts are not strong enough to support the weight of the transmitter and therefore must not be used to support or 'tie down' the transmitter to your mount. The alignment bolt threads inside the bottom of the transmitter are 10-24. Thread engagement will occur 1 ¾ inches into the base. You should screw the bolt in an additional ½ inch for full engagement but no more.

The cable from the transmitter to the ERC contains high voltages and currents and therefore must be protected so that it will not be stepped on. Run the cable through the ceiling or under the floor. If the cable is on the floor, use a rigid cable protector that can be walked on such as 'Cordgard- Electrical Cord Ducting' available through Arrow Electronics and other electrical and electronic distributors. Putting the cable under a piece of rug will not provide protection; it will only create a fire hazard.

2.3.3 ERC INTERNAL JUMPERS. If you must change the internal jumpers, note that there are dangerous voltages inside the enclosure. Turning the on/off switch to off will not remove the dangerous voltages. You must unplug the power cord before removing the enclosure top. To locate the jumpers, refer to the printed circuit card drawings in Appendix IV.

D A N G E R H I G H V O L T A G E

Remove the power cord from the ERC before opening to eliminate the dangerous high voltages inside.

2.3.4 CONFIGURING THE FLOCK WITH AN ERC. In general, the ERC is treated as just another pcBIRD that must be attached to the FBB and must have a bus address of 1 to 14 assigned via the dip switches on the ERC's front panel. As shipped from the factory, the ERC address is set to 1 (i.e. the default bus Master).

The ERC, in combination with the rest of the pcBIRDs, can interface to the user's host computer via either the RS232 or ISA interfaces. When using a single RS232 interface, the host must be attached to the ERC and the ERC must be the bus Master. When using individual ISA interfaces to each BIRD you can operate the ERC without an RS232 interface as long as the ERC is selected to be a Slave. In this configuration, you would send the Next Transmitter command to the bus Master to tell the Master the address of the ERC.

If you are going to use an external Sync signal to synchronize the Flock to minimize CRT noise, the ERC must be selected as a Slave since it does not have a Sync input. The Sync signals can only be utilized by the current bus Master.

2.3.5 ERC TRANSMITTER CABLE. The ERC can control up to two ERTs or with the expansion option installed, four ERTs. The front panel connectors are labeled 'XMTR' 1, 2, (3, 4). If you ordered one ERT, then all other connectors are capped. DO NOT REMOVE THESE CAP(S). They protect the user from exposure to high voltages. The ERC/ERT will not work if the cap is removed. Plug an ERT cable connector into the corresponding front panel connector and screw in the connector. Erratic system operation will result if the connector is not screwed in place.

D A N G E R H I G H V O L T A G E

Do not remove the protective caps from the unused ERC connectors.

2.3.6 ERC POWER SUPPLY CABLE. The ERC is shipped with a North American 110 volt power cord. If your country uses 220 volts, your local hardware/electrical store can supply you with the correct cable. Before installing the cable, switch the ON/OFF switch located directly above the cable connector to OFF. The switch is OFF when you can see 'O' on the side edge of the switch. The switch is 'ON' when you can see 'I' on the other side edge of the switch. Insert the power cable connector into the back panel. Push hard with a slight wiggle of the connector to completely engage the connector.

3.0 INCLUDED SOFTWARE

One high density 3.25 inch DOS formatted diskette is included with your unit. This diskette contains source code written in C. One of the programs on this diskette called CBIRD.EXE lets you send commands to the pcBIRD from a menu and read output data onto the screen or into a file. Additionally, this diskette contains complete, commented source code of all the 'C' functions you'll need for talking to the pcBIRD from your own program. See the file, C_FILES.TXT for a description of these functions. Additional programming notes for the 'C' user can be found in file CNOTES.TXT. Instructions for running the pcBIRD program are located in file OPERATEC.TXT.

Feel free to incorporate any of this software into your own application or product.

4.0 ISA HOST INTERFACE TO THE pcBIRD

If your host computer is using the RS232 interface to the Flock, you do not need to read Sections 4.x or 5.x. You should, however, read Section 6.x.

The ISA interface provides a 16 bit read/write data port located at Base Address+0 to exchange information between the pcBIRD and the user's host computer. In addition, at Base Address+2 the user can determine the status of the port's data availability, set the interrupt source or reset the pcBIRD system.

The user's host computer initiates all command and data transactions for the pcBIRD. The pcBIRD card interprets the most significant byte of the first word in a record as a command. Subsequent bytes/words sent to the card by the host may contain additional data or commands.

4.1 PORT DEFINITION

The bit definitions of the pcBIRD's two ISA ports as seen by the user's host computer are defined below:

Read/Write DATA AND COMMANDS at Base address+0

Most Significant Byte								Least Significant Byte							
B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0

Here, B0 is the least significant bit and B15 is the most significant bit of the commands and data written to or read from the pcBIRD.

Read only DATA STATUS at Base address+2

B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
X	X	X	X	X	X	X	X	X	X	X	X	X	X	RDR	TDR

RDR = Receive Data Ready
TDR = Transmit Data Ready

When B0 = 1, the user can transmit a word to the pcBIRD.
When B1 = 1, a word is available from pcBIRD for reading.
Bits B2 to B15 may be any random value when STATUS is read.

Write only INTERRUPT SOURCE and RESET/RUN at Base address+2

B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
X	X	X	X	X	X	X	X	X	X	X	X	X	X	INT	RST

RST = Reset/Run
INT = Interrupt source

Setting B0 = 0 holds the pcBIRD in reset.
Setting B0 = 1 starts or continues the operation of the pcBIRD .

Setting B1 = 0 sets the interrupt source to be the RDR status bit.
Setting B1 = 1 sets the interrupt source to be the TDR status bit.

The bits associated with READ operations from the port at Base Address+2 will hereafter be referred to as DATA STATUS bits. The bits associated with WRITE operations to the port at Base Address+2 will hereafter be referred to as INTERRUPT/RESET bits.

4.2 PORT BEHAVIOR ON POWER UP

On power up or immediately after a reset, the DATA STATUS bits are: B1 = 0, B0 = 0. Approximately two seconds after power up or reset, the DATA STATUS bits will change to B1 = 0, B0 = 1 indicating that there is no data available to read from the pcBIRD (B1 = 0), but the user can send a command to the pcBIRD (B0 = 1).

4.3 SENDING COMMANDS TO THE pcBIRD

To send a word to the pcBIRD, the user must first wait until the DATA STATUS bit B0 = 1. Immediately after the user sends a word, the DATA STATUS bit B0 is automatically set to zero. After the pcBIRD processes this word, B0 is again set to one indicating that the user can send another command or data word. If the previous command results in the pcBIRD outputting data to the user, the user must not issue a new command until the previous data is received. pcBIRD operation will become faulty if the user sends a word to the pcBIRD when the DATA STATUS bit B0 = 0.

4.4 RECEIVING DATA FROM THE pcBIRD

When the pcBIRD sends a word to the user, DATA STATUS bit B1 is set to one. Immediately after the user reads the data port to get this word, DATA STATUS bit B1 is automatically reset to zero. pcBIRD operation will become faulty if the user reads a data word when the DATA STATUS bit B1 = 0.

4.5 INTERRUPT OPERATION

To send commands and read data from the pcBIRD using interrupts, one must insert one of the IRQ jumpers on the board. You may, however, still use polling of the DATA STATUS register when an IRQ jumper is inserted if you mask this interrupt in your host computer. Behavior of the DATA STATUS bits during interrupt operation is the same as during polled operation. When either or both of the DATA STATUS bits are = 1, an interrupt will occur. To identify the source of the interrupt, the user must preset B1 in the INTERRUPT/RESET port to either a 0 or 1. When B1 has been preset = 0, an interrupt will be generated when the RDR status bit goes to 1. If the user has preset B1 = 1, an interrupt will be generated when the TDR status bit goes to 1. When you preset B1 to 0 or 1, be sure to keep B0 = 1 to keep the card from resetting.

4.6 RESETTING THE pcBIRD

To initialize or re-initialize the pcBIRD card using an ISA software command, write to Base address+2 with B0 = 0 followed immediately with a second write to Base Address+2 with B0 = 1. B1 can be any value when you initiate the reset. At the end of the reset, B1 is 1. The reset command can be sent at any time. If you have a Master/Slave configuration, the slave boards must be reset before the master.

After receiving the reset sequence, the pcBIRD will take approximately two seconds to initialize itself. It will then indicate that it is ready to accept user commands by setting DATA STATUS B0 = 1 and generating an interrupt if interrupts are enabled. Any commands or command data sent to the pcBIRD before or during the reset will be lost.

5.0 FORMAT OF ISA COMMANDS AND DATA

5.1 FORMAT OF COMMANDS AND DATA SENT

All commands sent to the pcBIRD consist of a single byte packed into a word. Associated with some commands are multiple byte command data. If you are sending only a command byte, this byte is positioned as the most significant byte in the output word. The least significant byte must be set to zero. For example, the following sends a "B" (42 Hex) to request data:

Most Significant Byte 42								Least Significant Byte 0							
B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0

To send two or more one-byte commands, you must send two or more words, one command per word as defined above.

If you are going to send a command that has command data associated with it, the command is positioned in the most significant byte of the first word to be output and the first byte of command data is positioned in the least significant byte. Additional command data fill up additional output words. If the last output word has only one byte, then the least significant byte of this word is set to zero. For example, the REFERENCE FRAME1 command "H" (48 Hex) has 6 command data words associated with it. For this example we'll assign the following Hex values to these data words: Sin(A) = 3618, Cos(A) = 7401, Sin(E) = 496A, Cos(E) = 68D9, Sin(R) = 7EDE, Cos(R) = 163A. The resulting seven words sent to the pcBIRD would be as follows:

Most Significant Byte 48								Least Significant Byte 36							
B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
0	1	0	0	1	0	0	0	0	0	1	1	0	1	1	0

Most Significant Byte 18								Least Significant Byte 74							
B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
0	0	0	1	1	0	0	0	0	1	1	1	0	1	0	0

Most Significant Byte 01								Least Significant Byte 49							
B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	1

Most Significant Byte 6A								Least Significant Byte 68							
B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
0	1	1	0	1	0	1	0	0	1	1	0	1	0	0	0

Most Significant Byte D9								Least Significant Byte 7E							
B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
1	1	0	1	1	0	0	1	0	1	1	1	1	1	1	0

Most Significant Byte DE								Least Significant Byte 16							
B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
1	1	0	1	1	1	1	0	0	0	0	1	0	1	1	0

Most Significant Byte 3A								Least Significant Byte zero pad							
B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
0	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0

In general, if you are sending N bytes of command and command data, you can format the data into a single string, left justified, adding an additional zero byte onto the end if required to make the string an even number of bytes. The string is then sent one word at a time to the pcBIRD.

5.2 FORMAT OF COMMANDS AND DATA RECEIVED

Two types of binary data are returned from the pcBIRD: 1) Position/Orientation data and 2) Change/Examine value data. Position/Orientation data are the data returned from the pcBIRD in the ANGLES, POSITION, MATRIX, POSITION/ANGLES, POSITION/MATRIX, POSITION/QUATERNION and QUATERNION formats. All other types of data that the pcBIRD returns are in the Change/Examine value format. Both Position/Orientation data and the Change/Examine value data return one or more 16 bit data words as detailed below.

5.2.1 POSITION/ORIENTATION DATA FORMAT.

The Position/Orientation information generated by the pcBIRD is returned to the user in a form called a “data record”. The number of words in each record is dependent on the output format selected by the user (i.e. Position, Angles etc.). Each word in the record is in a 16 bit 2's complement binary format. The binary format consists of the 15 most significant bits (bits B15 - B1) of the data plus a least significant bit B0 used as a "phasing" bit. The phasing bit allows the host computer to identify the start of a record. This phasing bit is set to one in the first word of a record and set to zero in all other words in the output record. You can ignore the effect of the phasing bit on the magnitude of the position and orientation data since the sixteenth bit is beyond the accuracy or resolution of the tracker.

5.2.2 CHANGE/EXAMINE DATA FORMAT.

The Change/Examine value data uses the response format described with each Change/Examine value command. The Change/Examine value data does not contain the “phasing” bits found in the Position/Orientation data. All 16 bits are used for data.

6.0 ISA COMMAND UTILIZATION

6.1 STAND ALONE OPERATION

After power up or reset, the pcBIRD is ready to output data to you in the POSITION/ANGLE format as soon as you send it a 'B' (POINT command). If you do not want POSITION/ANGLE formatted data, send one of the following data record select commands to the desired sensor: ANGLES, MATRIX, POSITION, QUATERNION, POSITION/ANGLES, POSITION/MATRIX, or POSITION/QUATERNION. These commands do not cause the pcBIRD to transmit data to the host. For the host to receive data, it must issue a data request. Use the POINT data request each time you want one data record or use the STREAM data request once to initiate a continuous flow of data records. If you want to reduce the rate at which data STREAMs from the pcBIRD, use the REPORT RATE command. All commands can be issued in any order and at any time to change the pcBIRD's output characteristics; however, if the previous command results in the pcBIRD outputting data to the user, the user must not issue a new command until the previous data is received. If you change the output format with an ANGLES, MATRIX, etc. command and immediately follow with a data request command, you will receive zero's for the data in the new format for up to 8 milliseconds until a new internal measurement cycle is started.

The following is a hypothetical command sequence issued after power-up which illustrates the use of some of the commands. These commands assume that the pcBIRD is in Stand Alone configuration.

COMMAND	ACTION
ANGLES	Specifies that the output record will contain angles only.
POINT	pcBIRD outputs an ANGLE data record.
POINT	pcBIRD outputs another ANGLE data record.
STREAM	ANGLE data records start streaming from pcBIRD.
OUTPUT BUFFER CLEAR	Stops the stream of ANGLE records, clears the output buffer.

6.2 MASTER/SLAVE OPERATION

When you use a single pcBIRD with an Extended Range Transmitter or multiple pcBIRDs (see Section 2.2.1.4) , a special command is used to start operation of all units. To start operation of the system, you must send to the master pcBIRD (the unit with address = 1) the CHANGE VALUE AUTO-CONFIGURATION command. Additionally, if the transmitter is not attached to the pcBIRD at address = 1, you must issue the NEXT TRANSMITTER command. After the units are running, you send commands to and receive data from each individual pcBIRD on the ISA bus as if it were in Stand Alone configuration. If you have multiple pcBIRDs running in different chassis interconnected with an FBB cable and you want to control their operation from the chassis containing the master pcBIRD, utilize the FBB ADDRESS command to control their operation.

6.3 BLINKING LED BEHAVIOR

As mentioned in the installation section, you may not want to close up your computer's case until you have verified that the pcBIRD is working and your application software has been debugged. There is a red light(LED) at the top rear edge of the pcBIRD card that is useful to view during initial hardware/software installation. The LED turns on when running and blinks when there is a hardware or software command error. The initial behavior of the pcBIRD after power up or reset depends on the mode of operation (Stand Alone or Master/Slave) selected by the configuration dip switches.

If the pcBIRD is configured for Stand Alone operation (one pcBIRD with a transmitter and sensor and with its address set = 0), on power up or reset the LED light will blink 5 times if in Normal Addressing mode, 2 times if in Expanded Addressing mode, or 1 time if in Super-Expanded Addressing mode and then turn on steady. At this time, the transmitter and sensor will begin operating, and the unit is ready to accept host commands. If during power up or reset, the electronics unit does not detect the presence of a transmitter or sensor or some other problem, the LED will blink a number of times corresponding to the error code value (refer to Section 11.0) i.e. if the error code was 32 the LED would blink 32 times, pause then repeat the 32 blinks. The error code can also be read via software using the EXAMINE VALUE/ERROR CODE command. When the LED is blinking due to an error, the pcBIRD does not output any position and orientation data. This behavior can be overridden by using the CHANGE VALUE/ERROR DETECT MASK command.

If configured for Master/Slave operation (several pcBIRD units interconnected by the multi-unit FBB cable with their individual addresses set = 1 through 30 via the dip switches), on power up the LED will blink 5 times if in Normal Address mode, 2 times if in Expanded Address mode, or 1 time if in Super-Expanded Address mode and then go off. The host computer must then send the master an AUTO-CONFIG command. On receipt of this command, the LEDs on all units will turn on. There will be no blinking if operating correctly. If there is a blinking, refer to Section 11.0 for the error codes. When configured for Master/Slave operation, the pcBIRD will not detect if a transmitter and sensor are present since they are not required of all units.

6.4 ISA COMMAND SUMMARY

The following summarizes the action of each command. The details of command usage are presented in Section 6.6. If you are using the RS232 interface, there are more commands listed in Section 8.1.1.

Command Name	Description
ANGLES	Data record contains 3 Euler rotation angles.
ANGLE ALIGN	Aligns a sensor to a specified direction.
BUTTON MODE	Sets how the mouse button will be output.
BUTTON READ	Reads the value of the mouse button pushed.
CHANGE VALUE	Changes the value of a selected system parameter.
EXAMINE VALUE	Reads and examines a selected system parameter.
FBB RESET	Resets all of the slave BIRDs.
HEMISPHERE	Sets desired hemisphere of transmitter operation.
MATRIX	Data record contains 9-element rotation matrix.
NEXT TRANSMITTER	Turns on the next transmitter.
OUTPUT BUFFER CLEAR	Stops any data being output and clears the output

	buffer. **This is an ISA command only**.
POINT	One data record is output for each B command from the selected sensor. If GROUP mode is enabled, one record is output from all configured sensors.
POSITION	Data record contains X, Y, Z position of sensor.
POSITION/ANGLES	Data record contains POSITION and ANGLES.
POSITION/MATRIX	Data record contains POSITION and MATRIX.
POSITION/QUATERNION	Data record contains POSITION and QUATERNION.
QUATERNION	Data record contains QUATERNIONs.
REFERENCE FRAME	Defines new measurement reference frame.
REPORT RATE	Number of data records/second output in STREAM mode.
RS232/ISA TO FBB	Address preface to allow a single pcBIRD to send commands and receive data from all other pcBIRDs.
RUN	Starts the system running again after put to SLEEP.
SLEEP	Turns transmitter off and suspends system operation.
STREAM	Data records are transmitted continuously from the selected sensor.
SYNC	Synchronizes data output to CRT or your host computer.

6.5 DEFAULT VALUES

Upon power-up or reset, the pcBIRD is configured as follows where all numbers are listed as base 10:

- POINT mode
- POSITION/ANGLE outputs selected
- REPORT RATE = Q (maximum)
- ANGLE ALIGN sines/cosines set for alignment angles of zero
- REFERENCE FRAME sines/cosines set for reference angles of zero
- FACTORY TEST commands not active
- Maximum range scaling = 36 inches
- Filter on/off status = AC WIDE notch on, DC on, AC NARROW notch off
- Filter constants ALPHA_MIN table values = 0.02
- Filter constants ALPHA_MAX table values = 0.9
- Filter constant Vm table values = 2, 4, 8, 32, 64, 256, 512
- Hemisphere = forward
- BUTTON MODE = 0 for no button value output
- SYNC mode = 0
- System measurement rate = 103.3 measurements/sec

6.6 ISA COMMAND USAGE TABLE

The following information answers the question "To which BIRD unit do I send a given command?" The answer depends on the type and number of interfaces and the command itself. The following table sorts out the possible combinations.

In the following, the word "flock" will mean several BIRD units interconnected with FBB cables. "BIRD" refers to a single unit with a sensor. "ERC" refers to the Extended Range Controller. "ERT" refers to the Extended Range Transmitter (the 12 inch black cube) that plugs into the ERC. The ERC does not have a sensor.

Applicability references

The command usage table refers to the numbers 2 to 6. Each of these numbers have the following meaning:

2. This command must be sent to the individual BIRD in the Flock whose mode of operation you want to change even if you are in the **GROUP** mode. If you send this command addressed to the Master, it will not change the mode of any other BIRD. If you have multiple pcBIRD cards in a common chassis, you can send commands and receive data by talking to each card individually using the ISA bus -- they do not have to be prefaced with the **RS232/ISA TO FBB** command. If you have pcBIRD cards in multiple chassis interconnected with an FBB bus and want to control them from a single chassis or an external ERC, you need to use the **RS232/ISA TO FBB** command.

3. This command is only sent to the Master unit. You may, but do not have to, use the **RS232/ISA TO FBB** preface on commands meant for the Master unit only. In fact, if the **RS232/ISA TO FBB** preface is missing, the Master assumes the command is for him alone.

4. Do not send this command to the address of the ERC.

5. Do not use this command if your system is using an ERC/ERT.

6. If in the **GROUP** mode, send this command only to the Master.

Notation shorthand

snsr = sensor
xmtr = transmitter
addr = address
exam/chg = examine/change

COMMAND USAGE TABLE

COMMAND	APPLICABILITY	NOTES
Angles	2, 4	Send to the addr of the snsr from which you want Angles data
Angle Align	2, 4	Send to the addr of the snsr whose orientation you want to change. If you send it to the Master unit, the Master will not disseminate the information to the sensors.
Button Mode	2, 4	Send to the addr of the snsr from which you want button outputs
Button Read	2, 4	Send to the addr of the snsr from which you want button outputs
Examine value parameter 0 BIRD Status	2	Send to the addr of the unit whose status you want to know
Examine value parameter 1 Software Rev	2	Send to the addr of the unit whose software rev you want to know
Examine value parameter 2 Crystal Speed	2	Send to the addr of the unit whose crystal speed you want to know
Exam/chg value parameter 3 Position Scaling	2, 4, 5	Send to the addr of the snsr whose range scaling you want to examine or change
Exam/chg value parameter 4 Filter On/Off	2, 4	Send to the addr of the snsr whose filtering you want to examine or change
Exam/chg value parameter 5 Alpha min	2, 4	Send to the addr of the snsr whose filtering you want to examine or change
Exam/chg value parameter 6 Measurement Rate	3	If a Flock, send to the Master only

COMMAND	APPLICABILITY	NOTES
Exam/chg value parameter 8 Enable Data Ready	3	If a Flock, send to the Master only
Exam/chg value parameter 9 Set Data Ready	3	If a Flock, send to the Master only
Examine value parameter 10 Error Code	2	Send to the addr of the unit whose error code you want to know
Exam/chg value parameter 11 Error Mask	2	Send to the addr of the pcBIRD unit where the error should be masked or examined
Exam/chg value parameter 12 DC Filter V_m	2, 4	Send to the addr of the snsr whose filtering you want to examine or change
Exam/chg value parameter 13 Alpha_max	2, 4	Send to the addr of the snsr whose filtering you want to examine or change
Exam/chg value parameter 14 Output Lock	2, 4	Send to the addr of the snsr whose outputs you want to lock or examine
Examine value parameter 15 Identification	2	Send to the addr of the unit whose system model identification you want to know
Examine value parameter 16 Expanded Error	3	Send to the Master to determine the addr of the Slave that did not respond
Exam/chg value parameter 17 XYZ Ref Frame	2, 4	Send to the addr of the snsr whose outputs you want measured in the rotated xmtr frame
Exam/chg value parameter 18 Transmitter Mode	2	This command must be sent to every BIRD in the flock
Examine value parameter 19 Addressing Mode	2	Send to the addr of the pcBIRD unit whose addressing mode you want to examine

COMMAND	APPLICABILITY	NOTES
Exam/chg value parameter 20 Filter Line Freq	2, 4	Send to the addr of the snsr whose filtering you want to examine or change
Examine value parameter 21 FBB Address	2	Send to the pcBIRD unit whose FBB address you want to know. Useful when communicating to the Flock through multiple RS232 interfaces or through the ISA Bus
Exam/chg value parameter 22 Hemisphere	2, 4	Send to the addr of the snsr whose hemisphere you want to examine or change
Exam/chg value parameter 23 Angle Align2	2, 4	Send to the addr of the snsr whose orientation you want to examine or change. If you send it to the Master unit, the Master will not disseminate the information to the sensors
Exam/chg value parameter 24 Reference Frame2	2	Send to the addr with the transmitter whose reference frame you want to examine or change
Examine value parameter 25 BIRD Serial Number	2, 4	Send to the addr of the pcBIRD unit whose pcb serial number you want to know
Examine value parameter 26 Sensor Serial Number	2, 4	Send to the addr of the pcBIRD unit whose snsr serial number you want to know
Examine value parameter 27 Xmtr Serial Number	2, 4	Send to the addr of the pcBIRD unit whose xmtr serial number you want to know
Exam/chg value parameter 35 Group Mode	3	Send to the Master only to examine or change group mode
Examine value parameter 36 Flock Status	3	Send to the Master only to examine Flock system status
Exam/chg value parameter 50 FBB Auto-Config	3	Send to the Master only
FBB Reset	3	Send to the Master only
Hemisphere	2, 4	Send to the addr of the snsr whose outputs you want to be in a given hemisphere

COMMAND	APPLICABILITY	NOTES
Matrix	2, 4	Send to the addr of the snsr from which you want Matrix data
Next Transmitter	3	Send to the current Master only
Output Buffer Clear	2, 4	Send to the addr of the pcBIRD whose Output Buffer you want to clear
Point	2, 6	If in Group mode send to the Master only. If not in group mode must use the **RS232/ISA TO FBB command to send to each individual sensor** if you have only one interface port. If you have an ISA interface port to each sensor, then just send the point command out each port.
Position	2, 4	Send to the addr of the snsr from which you want Position data
Position/Angles	2, 4	Send to the addr of the snsr from which you want Position/Angles data
Position/Matrix	2, 4	Send to the addr of the snsr from which you want Position/Matrix data
Position/Quaternion	2, 4	Send to the addr of the snsr from which you want Position/Quaternion data
Quaternion	2, 4	Send to the addr of the snsr from which you want Quaternion data
Reference Frame	3	Send to the Master before or after auto-config. After auto-config, send to the addr with the transmitter. Can also be sent to the address of each sensor individually.
Report Rate	6	Can only be used in standalone stream mode or in group stream mode
RS232/ISA to FBB	3	Send to the Master only
Run	3	
Sleep	3	
Stream	6	Cannot be used with a Flock unless in **GROUP** mode
Sync	3	Send to the Master only

7.0 RS232 HOST INTERFACE

If your host computer is using the ISA interface to the Flock, you do not need to read Section 7.x or 8.x. The RS232 section is included for those users who purchased the optional Extended Range Controller and transmitter.

7.1 RS232 SIGNAL DESCRIPTION

The RS-232C interface conforms to the Electronic Industries Association (EIA) specifications for data communications. A pin out and signal description of the RS-232C interface is found below. Note that the ERC requires connections only to pins 2, 3 and 5 of the 9-pin interface connector. The file named RS232.TXT on the pcBIRD software diskette contains additional information about the RS-232 interface to several different computers.

The ERC's 9-pin RS-232C connector is arranged as follows:

PIN	RS232 SIGNAL[1]	DIRECTION
1	Carrier Detect	BIRD to Host
2	Receive Data	BIRD to Host
3	Transmit Data	Host to BIRD
4	Data Terminal Rdy	Host to BIRD
5	Signal Ground	BIRD to Host
6	Data Set Ready	BIRD to Host
7	Request to Send	Host to BIRD
8	Clear to Send	BIRD to Host
9	Ring Indicator	No Connect

1) Note: These are the EIA RS232 signals names. The ERC is configured as Data Communication Equipment (DCE) and therefore Transmit Data is an input and Receive Data is an output.

RS-232C signal description:

SIGNAL	DESCRIPTION
Carrier Detect	Indicates the BIRD is FLYing when high[2]
Receive Data	Serial data output from the BIRD to the host
Transmit Data	Serial data output from the host to the BIRD
Data Terminal Rdy	Host data flow control, suspends all data transmission from the BIRD when low (internally pulled high to +12V).
Signal Ground	Signal reference
Data Set Ready	Indicates the BIRD is FLYing when high[2]
Request to Send	Holds the BIRD in standby when high, BIRD Flies when low
Clear to Send	Indicates the BIRD is FLYing when high[2]
Ring Indicator	Signal is not used

2) Note: These signals are high when the ERC is NOT in the reset (Off) condition. There are two ways by which the ERC can be placed in the reset condition: when the front panel switch is in the Off position or when the RS232 Request to Send signal is high.

7.2 RS232 TRANSMISSION CHARACTERISTICS

The host computer must be configured for the following data characteristics:

Baud Rate	2400 - 115,200 (as set by BIRD dip switch)
Number of data bits	8
Number of start bits	1
Number of stop bits	1
Parity	none
Full duplex	

7.3 RS232 JUMPER CONFIGURATION

For host communications to the ERC using RS232, set the following jumpers. See Appendix III for a description of these jumpers.

Jumper	Configuration
JPR 3	pins 1-2 no connection
JPR 12	pins 2-3 connected

7.4 RS232 DATA RATES

When your host computer is using an RS-232 interface to communicate with the BIRDs, it can utilize one serial port connected to the Master to communicate with the ERC, and/or a separate ISA interface for each pcBIRD in the Flock. Using a single RS232 port to talk to all BIRDs has the disadvantage of limiting the number of measurements per second that your host can read from each BIRD. Table 1 below shows the maximum data record output rate that can be obtained when using a single RS232 interface for all BIRDs. The rate that your host computer is able to obtain will be less than or equal to these table values depending on the time lags imposed by your host computer's operating system. For example, a UNIX operating system will slow the I/O down to such an extent that you may only be able to achieve one third of the maximum rates listed.

Table 1.
Maximum RS232 Data Record Output Rate

DATA OUTPUT FORMAT (Records Output/Sec/BIRD)				
Number of Sensors	Baud Rate	Position	Position/Angles	Position/Matrix
1 1 Master or 1 Slave	19.2K 38.4K 115.2K	203 309 515	113 206 412	66 120 219
2 1 Master 1 Slave	19.2K 38.4K 115.2K	102 154 257	57 103 206	33 60 108
3 1 Master 2 Slaves	19.2K 38.4K 115.2K	68 103 171	38 68 137	22 40 72
4 1 Master 3 Slaves	19.2K 38.4K 115.2K	51 77 128	28 51 103	16 30 54
5 1 Master 4 Slaves	19.2K 38.4K 115.2K	40 61 103	22 41 82	13 24 43
6 1 Master 5 Slaves	19.2K 38.4K 115.2K	34 51 85	19 34 68	11 20 36
7 1 Master 6 Slaves	19.2K 38.4K 115.2K	29 44 73	16 29 58	9 17 30
8 1 Master 7 Slaves	19.2K 38.4K 115.2K	25 38 64	14 25 51	8 15 27
10 1 Master 9 Slaves	19.2K 38.4K 115.2K	20 30 51	11 20 41	6 12 21

Notes: 1) The rates that are greater than 103.3 (the BIRD's default measurement rate) are not meant to imply that each BIRD is making this many measurements. Rather it indicates that you can request and receive data over the RS232 port at a rate greater than the BIRD is making its measurements. When you request data at a rate greater than the measurement rate, you will get duplicate data records. Rates less than 103.3 do not mean the BIRD is making measurements this slowly. The BIRDs are always making 103.3 measurements per second per sensor independent of how many sensors are in a Flock. When you request data at a rate less than the measurement rate, you will lose data records.
2) Rates for UNIX platforms will be much less than these table values.
3) Writes to the screen or disk will reduce these table values.

8.0 RUNNING THE FLOCK USING AN RS232 INTERFACE

The pcBIRDs in the Flock talk to each other via the FBB interconnect cable. To enable the pcBIRDs to exchange data among themselves, each BIRD is assigned a unique FBB address via the configuration dip switch (see Section 2.2.1.5). If you are using a separate ISA interface to talk to each pcBIRD, the commands you send to the pcBIRDs do not have a BIRD address associated with each command. If you utilize a single RS232 interface to talk to all of the pcBIRDs, the commands you send must contain the address of the pcBIRD that you want to respond (see the RS232/ISA TO FBB command).

8.1 RS232 COMMANDS

Each RS232 command consists of a single command byte followed by N command data bytes, where N depends upon the command. A command is an 8 bit value which the host transmits to the ERC using the format shown below.

The RS232 command format is as follows:

	MS BIT								LS BIT
	Stop	7	6	5	4	3	2	1	0	Start
RS232 Command	1	BC7	BC6	BC5	BC4	BC3	BC2	BC1	BC0	0

where BC7-BC0 is the 8 bit command value (see RS232 Command Reference) and the MS BIT (Stop = 1) and LS BIT (Start = 0) refers to the bit values that the UART in your computer's RS232 port automatically inserts into the serial data stream as it leaves the computer.

The RS232 command data format is as follows:

	MS BIT								LS BIT
	Stop	7	6	5	4	3	2	1	0	Start
RS232 Data	1	BD7	BD6	BD5	BD4	BD3	BD6	BD1	BD0	0

where BD7-BD0 is the 8 bit data value associated with a given command.

If you are going to use a single RS232 port to talk to all of the pcBIRDs in a Flock instead of separate ISA interfaces, you must preface each RS232 command with the RS232/ISA TO FBB command.

8.1.1 RS232 COMMAND SUMMARY. The following summarizes the action of each command. The details of command usage are presented in Section 8.4. If you are using the ISA interface, there are more commands listed in Section 6.6.

Command Name	Description
ANGLES	Data record contains 3 rotation angles.
ANGLE ALIGN	Aligns BIRD to reference direction.
BUTTON MODE	Sets how the mouse button will be output.
BUTTON READ	Reads the value of the mouse button pushed.
CHANGE VALUE	Changes the value of a selected BIRD system parameter.
EXAMINE VALUE	Reads and examines a selected BIRD system parameter.
FBB RESET	Resets all of the Slaves through the FBB.
HEMISPHERE	Tells BIRD desired hemisphere of operation.
MATRIX	Data record contains 9-element rotation matrix.
NEXT TRANSMITTER	Turns on the next transmitter in the Flock.
POINT	One data record is output for each B command from the selected Flock unit. If GROUP mode is enabled, one record is output from all running Flock units.
POSITION	Data record contains X, Y, Z position of sensor.
POSITION/ANGLES	Data record contains POSITION and ANGLES.
POSITION/MATRIX	Data record contains POSITION and MATRIX.
POSITION/QUATERNION	Data record contains POSITION and QUATERNION.
QUATERNION	Data record contains QUATERNIONs.
REFERENCE FRAME	Defines new measurement reference frame.

REPORT RATE	Number of data records/second output in STREAM mode.
RS232/ISA TO FBB	Use one RS232 interface connection to talk to all BIRDs.
RUN	Turns transmitter ON and starts running after SLEEP.
SLEEP	Turns transmitter OFF and suspends system operation.
STREAM	Data records are transmitted continuously from the selected Flock unit. If GROUP mode is enabled then data records are output continuously from all running Flock units.
SYNC	Synchronizes data output to a CRT or your host computer.
XON	Resumes data transmission that has been halted with XOFF. **This is an RS232 command only**.
XOFF	Halts data transmission from the ERC. **This is an RS232 command only**.

8.2 RS232 COMMAND UTILIZATION

8.2.1 POWER-UP BEHAVIOR

When the ERCs and pcBIRDs have power turned ON and if the host is not asserting the RTS (Bird RESET) signal on the RS232 interface, then the units will perform their power-up functions. During power-up, the units read their configuration dip switches and internal jumpers to determine their mode of operation.

On power-up, the ERC's front panel light and chassis back panel lights will blink 5 times if in Normal Address mode, 2 times if in Expanded Address mode, or 1 time if in Super-Expanded Address mode and then go off. The host computer must then send the Master (the unit with address = 1) the CHANGE VALUE AUTO-CONFIGURATION command. On receipt of this command, the lights on all units will turn ON and the Flock will start running. There will be no blinking if operating correctly. If there is a blinking, refer to Section 11.0 for the error codes.

The host may then tell the ERC what type of data to send when a data request is issued. The desired type of data is indicated by sending one of the following data record commands: ANGLES, MATRIX, POSITION, QUATERNION, POSITION/ANGLES, POSITION/MATRIX, or POSITION/QUATERNION. These commands do not cause the ERC to transmit data to the host. For the host to receive data, it must issue a data request. Use the POINT data request each time you want one data record or use the STREAM data request to initiate a continuous flow of data records from the BIRDs. If you want to reduce the rate at which data STREAMs from the ERC, use the REPORT RATE command. All commands can be issued in any order and at any time to change the ERC's output characteristics.

The following is a hypothetical command sequence issued after power-up which illustrates the use of some of the commands.

For a one transmitter/two sensor Flock configuration using individual ISA ports to each Flock unit: In this example the Master has one transmitter and the Slaves have the two sensors. All commands to the Master are sent over the Master's RS232 port and all commands to the Slave are sent over the Slave's ISA port.

COMMAND	ACTION
POSITION/MATRIX	Sent to the 1st Slave to select position and matrix for output.
POSITION/MATRIX	Sent to the 2nd Slave to select position and matrix for output.
CHANGE VALUE FBB AUTO- CONFIGURATION 3 Flock units	Sent to the Master to start the Flock running.
POINT	Sent to the 1st Slave to get one POSITION/MATRIX data record.
POINT	Sent to the 2nd Slave to get one POSITION/MATRIX data record.

For a one transmitter/two sensor Flock configuration with a single RS232 port attached to the Master: This one port will send commands and sensor data for both the Master and Slave. In this example, the Master has one transmitter and the Slaves have the two sensors.

COMMAND	ACTION
RS232/ISA TO FBB with FBB addr = 2	Lets the Master know that the next command goes to the Flock unit at addr = 2.
POSITION/MATRIX	1st Slaves output format will be position and matrix.
RS232/ISA TO FBB with FBB addr = 3	Lets the Master know that the next command goes to the Flock unit at addr = 3.
POSITION/MATRIX	2nd Slaves output format will be position and matrix.
CHANGE VALUE FBB AUTO-CONFIGURATION 3 Flock units	Sent to the Master to start the Flock running.
RS232/ISA TO FBB with FBB addr = 2	Lets the Master know that the next command goes to the Flock unit at addr = 2.
POINT	One POSITION/MATRIX data record returned from the 1st Slave.
RS232/ISA TO FBB with FBB addr = 3	Lets the Master know that the next command goes to the Flock unit at addr = 3.
POINT	One POSITION/MATRIX data record returned from the 2nd Slave.

The next configuration consists of an ERC configured as the Master and twelve Slave sensors with individual ISA ports to each unit. All commands to the Master are sent over the Master's RS232 port and all commands to the Slaves are sent over the Slave's individual ISA ports.

COMMAND	ACTION
POSITION/MATRIX	Sent to each Slave to select position and matrix for output.
CHANGE VALUE FBB AUTO-CONFIGURATION 13 Flock units	Sent to the Master to start the Flock running.
POINT	Sent to each Slave to get their POSITION/MATRIX data.

8.2.2 RS232/FLOCK MODE DEFAULT VALUES. Upon power-up, the RS232 controlled Flock BIRD (address = 1 through 126) is in the following default mode:

1. POINT mode
2. POSITION/ANGLE outputs selected
3. XON
4. RUN deactivated
6. ANGLE ALIGN sines/cosines set for alignment angles of zero
7. REFERENCE FRAME sines/cosines set for reference angles of zero
8. BUTTON MODE = 0 for no button value output
9. FACTORY TEST commands not active
10. Maximum range scaling = 36 inches
11. Filter on/off status = AC WIDE notch on, DC on, AC NARROW notch off
12. Filter constants ALPHA_MIN Table values = 0.02
13 Filter constants ALPHA_MAX Table values = 0.9
14 Sudden output change lock = 0 allows sudden changes to be output
15. System measurement rate = 100 measurements/sec
16. SYNC mode = 0
17. Group Mode = 0

8.3 RS232 RESPONSE FORMAT

Two types of binary data are returned from the ERC: 1) Position/Orientation data and 2) Change/Examine value data. Position/orientation data are the data returned from the ERC in the ANGLES, POSITION, MATRIX, POSITION/ANGLES, POSITION/MATRIX, POSITION/QUATERNION and QUATERNION formats. All other types of data that the ERC returns are in the change/examine value format. Both Position/Orientation data and the Change/Examine value data return one or more 8 bit data bytes as detailed below.

Position/Orientation data uses a special format, described in the following paragraphs. The Change/Examine value data uses the response format described with each Change/Examine value command in the RS232 Command section. The Change/Examine value data is not shifted and does not contain the 'phasing' bits found in the Position/Orientation data.

8.3.1 POSITION/ORIENTATION DATA FORMAT. The Position/Orientation information generated by the ERC is sent in a form called a data record. The number of bytes in each record is dependent on the output format selected by the user. Each 2-byte word is in a binary format dependent on the word type (i.e. Position, Angles, etc.). The binary formats consist of the 14 most significant bits (bits B15 - B2) of the sixteen bits (bits B15 - B0) which define each word. The two least significant bits (bits B1 and B0) are not used by the ERC. The first bit of the first byte transmitted is always a one (1) while the first bit of all other transmitted bytes in the record is always a zero (0). These "phasing" bits are required for the host computer to identify the start of a record when the data is streaming from the ERC without individual record requests. In general, the output data will appear as follows:

MS BIT							LS BIT	
7	6	5	4	3	2	1	0	WORD #
1	B8	B7	B6	B5	B4	B3	B2	#1 LSbyte
0	B15	B14	B13	B12	B11	B10	B9	#1 MSbyte
0	C8	C7	C6	C5	C4	C3	C2	#2 LSbyte
0	C15	C14	C13	C12	C11	C10	C9	#2 MSbyte
0	.	.	.	.	.	.	.	.
0	.	.	.	.	.	.	.	.
0	.	.	.	.	.	.	.	.
0	N8	N7	N6	N5	N4	N5	N2	#N LSbyte
0	N15	N14	N13	N12	N11	N10	N9	#N MSbyte
0	0	0	AD4	AD3	AD2	AD1	AD0	GROUP MODE address

The MS (most significant) bits are the phasing bits and are not part of the data. The GROUP MODE address byte is only present if GROUP MODE is enabled (see change value GROUP MODE).

For example, the ERC is about to send a data record consisting of these three data words:

Word#	Decimal	Hex	Binary (2 bytes) MSbyte	LSbyte
#1	4386	1122	00010001	00100010
#2	13124	3344	00110011	01000100
#3	21862	5566	01010101	01100110

The conversion to the binary data format that the ERC does goes like this:

BIRD

1) Shifts each data word right one bit

MS	LS
00001000	10010001
00011001	10100010
00101010	10110011

2) Breaks each word into MSByte LSByte pairs

10010001	LS
00001000	MS
10100010	LS
00011001	MS
10110011	LS
00101010	MS

3) Shifts each LSByte right one more bit (Marks with "1" if first byte)

4) Transmits all bytes in stream

MS BIT 7	6	5	4	3	2	1	LS BIT 0	WORD #
1	1	0	0	1	0	0	0	#1 LSByte
0	0	0	0	1	0	0	0	#1 MSByte
0	1	0	1	0	0	0	1	#2 LSByte
0	0	0	1	1	0	0	1	#2 MSByte
0	1	0	1	1	0	0	1	#3 LSByte
0	0	1	0	1	0	1	0	#3 MSByte

The user's computer can identify the beginning of the data record by catching the leading "1" and converting subsequent data bytes back to their proper binary values.

HOST:

1) Receives data bytes in stream after catching first marked "1" (Changes that "1" back to a "0")

01001000	LS
00001000	MS
01010001	LS
00011001	MS
01011001	LS
00101010	MS

2) Shifts each LSByte left one bit

10010000	LS
00001000	MS
10100010	LS
00011001	MS
10110010	LS
00101010	MS

3) Combines each MSByte/LSByte pair into data words

MS	LS
00001000	10010000
00011001	10100010
00101010	10110010

4) Shifts each word left one more bit, giving the correct original binary value

MS	LS
00010001	00100000
00110011	01000100
01010101	01100100

You don't need to worry about the fact that the two least significant bits are different because the data words do not use these bits.

NOTE: The GROUP MODE address and data sent by the ERC to the host in response to the BUTTON READ or EXAMINE VALUE commands are not shifted and have no phasing bit added.

8.4 RS232 COMMAND USAGE TABLE

The following information answers the question "To which BIRD unit do I send a given command?" The answer depends on the type and number of interfaces and the command itself. The following table sorts out the possible combinations.

In the following, the word "flock" will mean several BIRD units interconnected with FBB cables. "BIRD" refers to a single unit with a sensor. "ERC" refers to the Extended Range Controller. "ERT" refers to the Extended Range Transmitter (the 12 inch black cube) that plugs into the ERC. The ERC does not have a sensor.

Applicability references

The command usage table refers to the numbers 2 to 6. Each of these numbers have the following meaning:

2. This command must be sent to the individual BIRD in the Flock whose mode of operation you want to change even if you are in the **GROUP** mode. If you send this command addressed to the Master, it will not change the mode of any other BIRD. If you have multiple pcBIRD cards in a common chassis, you can send commands and receive data by talking to each card individually using the ISA bus -- they do not have to be prefaced with the **RS232/ISA TO FBB** command. If you have pcBIRD cards in multiple chassis interconnected with an FBB bus and want to control them from a single chassis or an external ERC, then you need to use the **RS232/ISA TO FBB** command.

3. This command is only sent to the Master unit. You may, but do not have to, use the **RS232/ISA TO FBB** preface on commands meant for the Master unit only. In fact, if the **RS232/ISA TO FBB** preface is missing, the Master assumes the command is for him alone.

4. Do not send this command to the address of the ERC.

5. Do not use this command if your system is using an ERC/ERT.

6. If in the **GROUP**, mode send this command only to the Master.

Notation shorthand

snsr = sensor
xmtr = transmitter
addr = address
exam/chg = examine/change

COMMAND USAGE TABLE

COMMAND	APPLICABILITY	NOTES
Angles	2, 4	Send to the addr of the snsr from which you want Angles data
Angle Align	2, 4	Send to the addr of the snsr whose orientation you want to change. If you send it to the Master unit, the Master will not disseminate the information to the sensors.
Button Mode	2, 4	Send to the addr of the snsr from which you want button outputs
Button Read	2, 4	Send to the addr of the snsr from which you want button outputs
Examine value parameter 0 BIRD Status	2	Send to the addr of the unit whose status you want to know
Examine value parameter 1 Software Rev	2	Send to the addr of the unit whose software rev you want to know
Examine value parameter 2 Crystal Speed	2	Send to the addr of the unit whose crystal speed you want to know
Exam/chg value parameter 3 Position Scaling	2, 4, 5	Send to the addr of the snsr whose range scaling you want to examine or change
Exam/chg value parameter 4 Filter On/Off	2, 4	Send to the addr of the snsr whose filtering you want to examine or change
Exam/chg value parameter 5 Alpha min	2, 4	Send to the addr of the snsr whose filtering you want to examine or change
Exam/chg value parameter 6 Measurement Rate	3	If a Flock, send to the Master only

COMMAND	APPLICABILITY	NOTES
Exam/chg value parameter 8 Enable Data Ready	3	If a Flock, send to the Master only
Exam/chg value parameter 9 Set Data Ready	3	If a Flock, send to the Master only
Examine value parameter 10 Error Code	2	Send to the addr of the unit whose error code you want to know
Exam/chg value parameter 11 Error Mask	2	Send to the addr of the pcBIRD unit where the error should be masked or examined
Exam/chg value parameter 12 DC Filter V_m	2, 4	Send to the addr of the snsr whose filtering you want to examine or change
Exam/chg value parameter 13 Alpha_max	2, 4	Send to the addr of the snsr whose filtering you want to examine or change
Exam/chg value parameter 14 Output Lock	2, 4	Send to the addr of the snsr whose outputs you want to lock or examine
Examine value parameter 15 Identification	2	Send to the addr of the unit whose system model identification you want to know
Examine value parameter 16 Expanded Error	3	Send to the Master to determine the addr of the Slave that did not respond
Exam/chg value parameter 17 XYZ Ref Frame	2, 4	Send to the addr of the snsr whose outputs you want measured in the rotated xmtr frame
Exam/chg value parameter 18 Transmitter Mode	3	This command must be sent to every BIRD in the flock
Examine value parameter 19 Addressing Mode	2	Send to the addr of the pcBIRD unit whose addressing mode you want to examine

COMMAND	APPLICABILITY	NOTES
Exam/chg value parameter 20 Filter Line Freq	2, 4	Send to the addr of the snsr whose filtering you want to examine or change
Examine value parameter 21 FBB Address	2	Send to the pcBIRD unit whose FBB address you want to know. Useful when communicating to the Flock through multiple RS232 interfaces or through the ISA Bus
Exam/chg value parameter 22 Hemisphere	2, 4	Send to the addr of the snsr whose hemisphere you want to examine or change
Exam/chg value parameter 23 Angle Align2	2, 4	Send to the addr of the snsr whose orientation you want to examine or change. If you send it to the Master unit, the Master will not disseminate the information to the sensors
Exam/chg value parameter 24 Reference Frame2	2	Send to the addr with the transmitter whose reference frame you want to examine or change
Examine value parameter 25 BIRD Serial Number	2, 4	Send to the addr of the pcBIRD unit whose pcb serial number you want to know
Examine value parameter 26 Sensor Serial Number	2, 4	Send to the addr of the pcBIRD unit whose snsr serial number you want to know
Examine value parameter 27 Xmtr Serial Number	2, 4	Send to the addr of the pcBIRD unit whose xmtr serial number you want to know
Exam/chg value parameter 32 FBB Host Delay	2	Only applicable when using an RS485 interface
Exam/chg value parameter 35 Group Mode	3	Send to the Master only to examine or change group mode
Examine value parameter 36 Flock Status	3	Send to the Master only to examine Flock system status
Exam/chg value parameter 50 FBB Auto-Config	3	Send to the Master only
FBB Reset	3	Send to the Master only

COMMAND	APPLICABILITY	NOTES
Hemisphere	2, 4	Send to the addr of the snsr whose outputs you want to be in a given hemisphere
Matrix	2, 4	Send to the addr of the snsr from which you want Matrix data
Next Transmitter	3	Send to the current Master only
Point	2, 6	If in Group mode send to the Master only. If not in group mode must use the **RS232/ISA TO FBB command to send to each individual sensor** if you have only one interface port. If you have an ISA interface port to each sensor, just send the point command out each port.
Position	2, 4	Send to the addr of the snsr from which you want Position data
Position/Angles	2, 4	Send to the addr of the snsr from which you want Position/Angles data
Position/Matrix	2, 4	Send to the addr of the snsr from which you want Position/Matrix data
Position/Quaternion	2, 4	Send to the addr of the snsr from which you want Position/Quaternion data
Quaternion	2, 4	Send to the addr of the snsr from which you want Quaternion data
Reference Frame	3	Send to the Master before or after auto-config. After auto-config, send to the addr with the transmitter. Can also be sent to the address of each sensor individually.
Report Rate	6	Can only be used in standalone stream mode or in group stream mode
RS232/ISA to FBB	3	Send to the Master only
Run	3	
Sleep	3	
Stream	6	Cannot be used with a Flock unless in **GROUP** mode
Sync	3	Send to the Master only
Xoff	3	
Xon	3	

9.0 TEST MODES

When the configuration dip switch position 8 is on (down), the pcBIRD is in test mode and the LED light will blink at a regular rate. The user can select test 1 through 31 using dip switches 4 through 7 as follows: (Remember you must reset or cycle the power on the pcBIRD to initiate the desired test.)

Dip switch						
4	5	6	7	8	Test Number	TEST
off	off	off	off	on	1	Factory Test
off	off	off	on	on	3	BIRD Output
off	off	on	off	on	5	BIRD Echo
off	off	on	on	on	7	Host Data Read
off	on	off	off	on	9	Host Data Read Block
off	on	off	on	on	11	Set 500K Baud Internal FBB
off	on	on	off	on	13	Set 625K Baud Internal FBB
off	on	on	on	on	15	<unused>
on	off	off	off	on	17	Factory Test
on	off	off	on	on	19	Factory Test
on	off	on	off	on	21	Test for sensor
on	off	on	on	on	23	Don't test for sensor
on	on	off	off	on	25	<unused>
on	on	off	on	on	27	Set Expanded Address mode
on	on	on	off	on	29	Set Normal Address Mode
on	on	on	on	on	31	Set Super-Expanded Address Mode

Note: After power-up tests have been successfully completed, the pcBIRD's LED will blink the following number of times depending on which address mode it is in:

Normal Addressing Mode	LED blinks 5 times
Expanded Addressing Mode	LED blinks twice
Super-Expanded Addressing Mode	LED blinks once

9.1 FACTORY TEST

This test is used during the manufacturing process of the pcBIRD.

9.2 BIRD OUTPUT

During the BIRD Output test, the pcBIRD will output 4 characters, 'O' (4F Hex), 'K' (4B Hex), <CR> (0D Hex), <LF> (0A Hex), approximately twice per second over the RS232 interface, depending on the host control mode. The user can validate the host cable and serial communication receive software with this test.

9.3 BIRD ECHO

During the BIRD Echo test, the pcBIRD will echo every character received over the RS232 interface. Using this test, the user can validate the host interface hardware and software.

9.4 HOST DATA READ

During the Host Data Read test, the pcBIRD will send one 8 bit character, 0 through 255 Decimal, each time it receives any character over the RS232 interface. The first character sent by the pcBIRD will be a 0, then a 1, 2, 3 and so on. Using this test, the user can verify that the host computer can receive all binary characters. This will help UNIX users to configure the serial port (TTY) to assure that the operating system is passing all 8 bit characters.

9.5 HOST DATA READ BLOCK

During the Host Data Read Block test, the pcBIRD will send a block of 8 bit characters, 0 through 255 Decimal, each time it receives any character over the RS232 interface. The block consists of 256 characters where the first will be a 0, then a 1, 2, 3 and so on. Using this test, the user can verify that the computer's operating system can receive a large number of binary characters at the desired baud rate without problems.

9.6 TEST FOR SENSOR

Selecting this test burns a bit into an on board EEPROM memory that tells the pcBIRD to test for the presence of a sensor on power up. This is the default factory setting. If a sensor is not attached to the pcBIRD on power up, the LED on the circuit card will blink an error code and the error register will be set.

9.7 DON'T TEST FOR SENSOR

Selecting this test burns a bit into an on board EEPROM memory that tells the pcBIRD not to test for the presence of a sensor on power up. If a sensor is not attached to the pcBIRD, there will be no error blinking or error reporting while this no test bit is burned in. It is useful to set this condition if you are using your pcBIRD in a multi-card configuration where a given card may only have a transmitter and not a sensor.

9.8 SET NORMAL ADDRESS MODE

This sets the ERC and pcBIRD cards into Normal Addressing Mode, which enables FBB addresses 1 through 14. The mode is stored in the internal non-volatile memory. To set the unit into Normal Addressing Mode, select test #29 and turn the power on. When the front panel indicator blinks, Normal Addressing Mode has been set. The dip switch can then be reset with the correct baud rate and address. The power switch must then be cycled for Normal Address operation. The ERC and all MotionStar sensor cards must be individually set to Normal Address Mode. When a pcBIRD is in Normal Address mode, its light will blink 5 times then go out when it is powered-up.

9.9 SET EXPANDED ADDRESS MODE

This sets the ERC and pcBIRD cards into Expanded Addressing Mode, which enables FBB addresses 1 through 30. To set the unit into Expanded Addressing Mode, select test #27 and turn the power on. When the front panel indicator blinks, Expanded Addressing Mode has been set. The dip switch can then be reset with the proper address and baud rate. The power switch must then be cycled for Expanded Address operation. The ERC and all pcBIRD cards must be individually set to Expanded Address Mode. When a pcBIRD is in expanded address mode, its light will blink 2 times then go out when it is powered-up.

9.10 SET SUPER-EXPANDED ADDRESS MODE

This sets the ERC and pcBIRD cards into Super-Expanded Addressing Mode, which enables FBB addresses 1 through 126. To set the unit into Super-Expanded Addressing Modes, select test #31 and turn the power on. When the front panel indicator blinks, Super-Expanded Addressing Mode has been set. The dip switch can then be reset with the proper address and baud rate. The power switch must then be cycled for Super-Expanded Address operation. The ERC and all pcBIRD cards must be individually set to Super-Expanded Address Mode. When a pcBIRD is in Super-Expanded Address mode, its light will blink 1 time then go out when it is powered-up.

10.0 COMMAND REFERENCE

All commands are listed alphabetically in the following section. Each command description contains the command codes required to initiate the commands along with the format and scaling of the data records which the pcBIRD will output to the host computer.

ANGLES **ANGLES**

	ASCII	HEX	DECIMAL	BINARY
Command Byte	W	57	87	01010111

In the ANGLES mode, the pcBIRD outputs the orientation angles of the sensor with respect to the transmitter. The orientation angles are defined as rotations about the Z, Y, and X axes of the sensor. These angles are called Zang, Yang, and Xang or, in Euler angle nomenclature, Azimuth, Elevation, and Roll. The output record is in the following format for the three transmitted words:

```
MSB                                                                   LSB
 15   14   13   12   11   10   9   8   7   6   5   4   3   2   1   0

Z15  Z14  Z13  Z12  Z11  Z10  Z9  Z8  Z7  Z6  Z5  Z4  Z3  Z2  Z1   1      Zang
Y15  Y14  Y13  Y12  Y11  Y10  Y9  Y8  Y7  Y6  Y5  Y4  Y3  Y2  Y1   0      Yang
X15  X14  X13  X12  X11  X10  X9  X8  X7  X6  X5  X4  X3  X2  X1   0      Xang
```

Zang (Azimuth) takes on values between the binary equivalent of +/- 180 degrees. Yang (Elevation) takes on values between +/- 90 degrees, and Xang (Roll) takes on values between +/- 180 degrees. As Yang (Elevation) approaches +/- 90 degrees, the Zang (Azimuth) and Xang (Roll) become very noisy and exhibit large errors. At 90 degrees the Zang (Azimuth) and Xang (Roll) become undefined. This behavior is not a limitation of the pcBIRD -- it is an inherent characteristic of these Euler angles. If you need a stable representation of the sensor orientation at high Elevation angles, use the MATRIX output mode.

The scaling of all angles is full scale = 180 degrees. That is, +179.99 deg = 7FFF Hex, 0 deg = 0 Hex, -180.00 deg = 8000 Hex.

Angle information is 0 when sensor saturation occurs in Expanded Addressing mode or Super-Expanded Addressing mode.

To convert the numbers into angles, first cast it into a signed integer. This will give you a number from +/- 32767. Second, multiply by 180 and then divide the number by 32767 to get the angle. The equation should look something like this:

(signed int(Hex #) * 180) / 32767

ANGLE ALIGN1 **ANGLE ALIGN1**

	ASCII	HEX	DECIMAL	BINARY
Command Byte	J	4A	74	01001010

Command Data	Sin(A)	Cos(A)	Sin(E)	Cos(E)	Sin(R)	Cos(R)

By default, the angle outputs from the pcBIRD are measured in the coordinate frame defined by the transmitter's X, Y and Z axes, as shown in Figure 5, and are measured with respect to rotations about the physical X, Y and Z axes of the sensor. The ANGLE ALIGN1 command allows you to mathematically change the sensor's X, Y and Z axes to an orientation which differs from that of the actual sensor.

For example:

Suppose that during installation you find it necessary, due to physical requirements, to cock the sensor, resulting in its angle outputs reading Azim = 5 deg, Elev = 10 and Roll = 15 when it is in its normal "resting" position. To compensate, use the ANGLE ALIGN1 command, passing as Command Data the sines and cosines of 5, 10 and 15 degrees. After this sequence is sent, the sensor outputs will be zero, and orientations will be computed as if the sensor were not misaligned.

Note: the ANGLE ALIGN1 command only affects the computation of orientation -- it has no effect on position.

If you immediately follow the ANGLE ALIGN1 command with a POINT or STREAM mode data request, you may not see the effect of the ALIGN command in the data returned. It will take at least one measurement period (i.e. 10 milliseconds if running the pcBIRD at 100 measurements/sec) before you see the effect of the command.

The host computer must send the Command Data immediately after the Command Byte. The Command Data consists of the sines and cosines of the Azimuth (A), Elevation (E), and Roll (R) angles that specify the amount of sensor misalignment you want to remove. Use the ANGLE ALIGN2 command for sending the angles instead of the sines and cosines of the angles. The Command Data must be sent even if the angles are zero.

The sequence of output words to the pcBIRD takes the following form:

WORD #	Most Significant Byte	Least Significant Byte
1	ALIGN command = 4A	MSbyte Sin (A)
2	LSbyte Sin (A)	MSbyte Cos (A)
3	LSbyte Cos (A)	MSbyte Sin (E)
4	LSbyte Sin (E)	MSbyte Cos (E)
5	LSbyte Cos (E)	MSbyte Sin (R)
6	LSbyte Sin (R)	MSbyte Cos (R)
7	LSbyte Cos (R)	0

The sine and cosine elements take values between the binary equivalents of +.99996 and -1.0.

Element scaling is +.99996 = 7FFF Hex, 0 = 0 Hex, and -1 = 8000 Hex.

ANGLE ALIGN2 **ANGLE ALIGN2**

	ASCII	HEX	DECIMAL	BINARY
Command Byte	q	71	113	01110001

Command Data	A, E, R

This command is the same as the ANGLE ALIGN1 command except that the command data consists of the angles only and not the sines and cosines of the angles.

The sequence of output words to the pcBIRD takes the following form:

WORD #	Most Significant Byte	Least Significant Byte
1	ALIGN command = 71	MSbyte A
2	LSbyte A	MSbyte A
3	LSbyte A	MSbyte E
4	LSbyte E	MSbyte E
5	LSbyte E	MSbyte R
6	LSbyte R	MSbyte R
7	LSbyte R	0

See the ANGLES command for the format and scaling of the angle values sent.

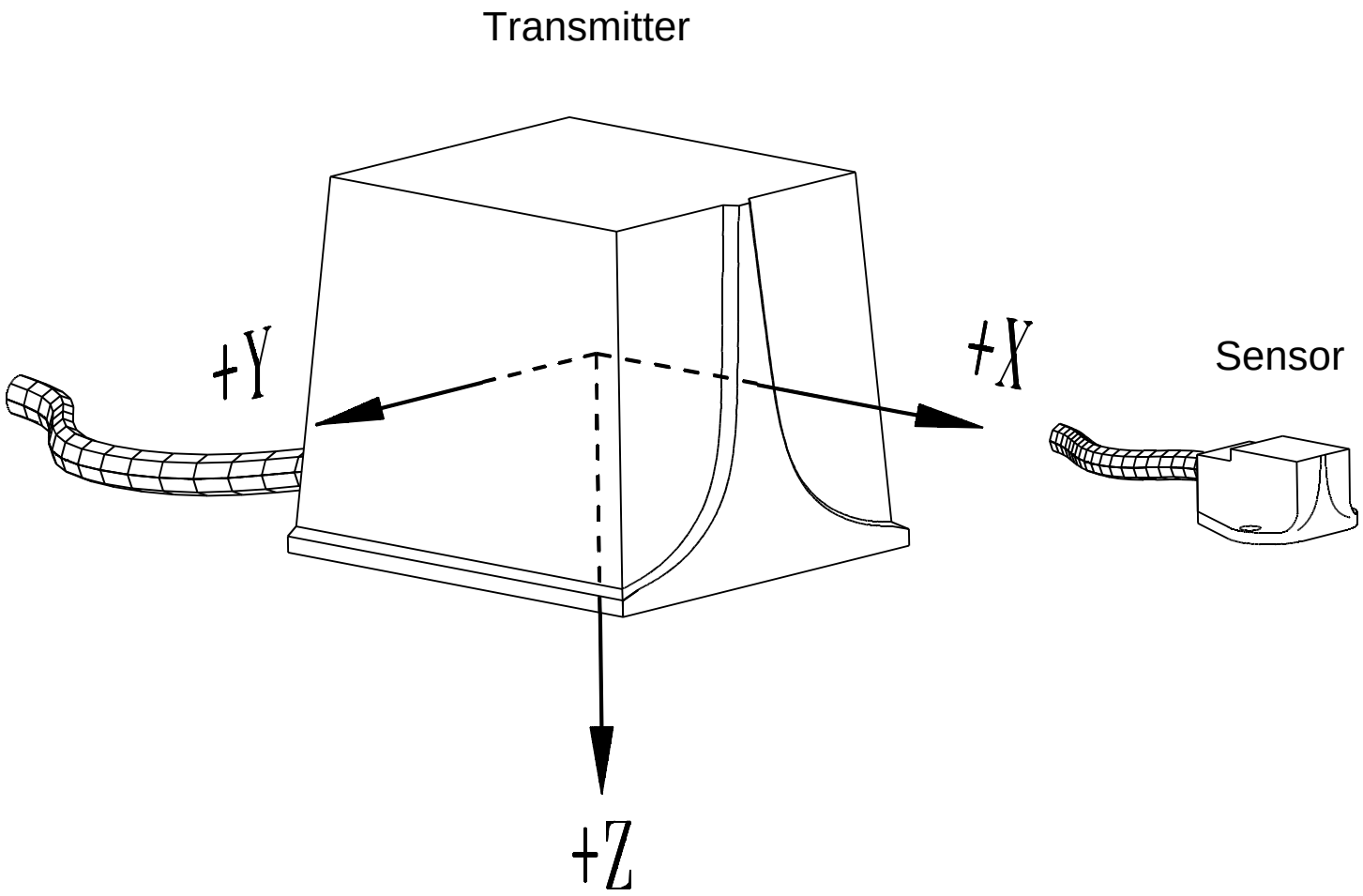


Figure 5. Measurement Reference Frame

BUTTON MODE **BUTTON MODE**

	ASCII	HEX	DECIMAL	BINARY
Command Byte	M	4D	77	01001101

Command Byte	MODE

The BUTTON MODE command is used to set how the three buttons on the optional 6D mouse will be reported to the host computer. The BUTTON MODE Command Byte must be followed by a single Command Data byte which specifies the desired report format. The three buttons are reported to the host via a single Button Value word. This word can be sent by the pcBIRD after the last data record element is transmitted or can be read at any time using the BUTTON READ command. If you set the Command Data byte equal to 0 Hex, the Button Value word is not appended to the data record, and you must use the BUTTON READ command to examine the status of the buttons. If you set the Command Data byte equal to 1, the Button Value word will be appended to the end of each transmitted data record. If, for example, you had selected the POSITION/ANGLE mode, the output sequence would now be:
x, y, z, az, el, rl, button, for a total of 14 bytes instead of the normal 12 bytes.

The BUTTON MODE command must be issued to the pcBIRD in the following 2-byte sequence:

MSB 7	6	5	4	3	2	1	LSB 0	BYTE #
0	1	0	0	1	1	0	1	#1 Command Byte
0	0	0	0	0	0	0	D0	#2 Command Data

Where D0 is either 0 or 1.

For a description of the values which may be returned in the Button Value word, see the BUTTON READ command.

BUTTON READ **BUTTON READ**

	ASCII	HEX	DECIMAL	BINARY
Command Byte	N	4E	78	01001110

The BUTTON READ command allows you to determine at any time which of the three buttons on the optional 6D mouse was pressed. This command is especially useful when you want to read the buttons but do not have BUTTON MODE set to 1 (which would append the Button Value word to every transmitted record).

Immediately after you send the BUTTON READ Command Byte, the pcBIRD will return a single word containing the Button Value. The Button Value word can assume the following Hex values:

0 Hex = 0: No button pressed.
10 Hex = 16: Left button pressed.
30 Hex = 48: Middle (or middle and left) button pressed.
70 Hex = 112: Right (or right and any other) button pressed.

Notes: The Button Value word does not contain the phasing bits normally included in the pcBIRD's transmitted data records. The above values are the ones actually sent to the host.

The pcBIRD updates its button reading every 0.01 seconds, whether you request the value or not. Thus, the system does not store previous button presses and indicates only whether a button has been pressed within 0.01 seconds (at the default update rate) of the time the reading is sent to the host.

CHANGE VALUE
EXAMINE VALUE

CHANGE VALUE
EXAMINE VALUE

	ASCII	HEX	DECIMAL	BINARY
CHANGE VALUE Command Byte	P	50	87	0101000

CHANGE VALUE Command Byte	PARAMETERnumber	PARAMETERvalue

The CHANGE VALUE command allows you to change the value of the pcBIRD system parameter defined by the PARAMETERnumber byte and the PARAMETERvalue byte(s) sent with the command.

	ASCII	HEX	DECIMAL	BINARY
EXAMINE VALUE Command Byte	O	4F	79	01001111

EXAMINE VALUE Command Byte	PARAMETERnumber

The EXAMINE VALUE command allows you to read the value of the pcBIRD system parameter defined by the PARAMETERnumber sent with the command. Immediately after the pcBIRD receives the command and command data, it will return the parameter value as a multi-word response.

Valid CHANGE VALUE and EXAMINE VALUE PARAMETERnumbers are listed in the table below. Note: not all PARAMETERnumbers are CHANGEable, but ALL are EXAMINEable.

PARAMETERnumber		CHANGEable	PARAMETER DESCRIPTION
Dec	Hex		
0	0	No	BIRD status
1	1	No	Software revision number
2	2	No	BIRD computer crystal speed
3	3	Yes	Position scaling
4	4	Yes	Filter on/off status
5	5	Yes	DC Filter constant table ALPHA_MIN
6	6	Yes	BIRD measurement rate count
7	7	Yes	BIRD measurement rate
8	8	Yes	Disable/Enable data ready output character
9	9	Yes	Changes data ready character
10	A	No	BIRD outputs an error code
11	B	Yes	On error: stop or don't stop BIRD operation
12	C	Yes	DC filter constant table Vm
13	D	Yes	DC filter constant table ALPHA_MAX
14	E	Yes	Sudden output change elimination
15	F	No	System Model Identification
16	10	No	Expanded Error Code
17	11	Yes	XYZ Reference Frame
18	12	Yes	Transmitter Operation Mode
19	13	No	FBB addressing mode
20	14	Yes	Filter line frequency
21	15	No	FBB address
22	16	Yes	Change/Examine Hemisphere
23	17	Yes	Change/Examine Angle Align2
24	18	Yes	Change/Examine Reference Frame2
25	19	No	BIRD Serial Number
26	1A	No	Sensor Serial Number
27	1B	No	Xmtr Serial Number
35	23	Yes	Group Mode
36	24	No	Flock System Status
50	32	Yes	FBB Auto-Configuration - 1 xmtr/N snsrs

To send the CHANGE VALUE command, position the CHANGE VALUE command in the most significant byte of the first word to be output and the PARAMETERnumber in the least significant byte. Any PARAMETERvalues required fill up additional output words. The N + 1 words sent to the pcBIRD are packed as follows:

WORD #	Most Significant Byte	Least Significant Byte
1	CHANGE command = 50 Hex	PARAMETERnumber
2	MSbyte of PARAMETERvalue 1	LSbyte of PARAMETERvalue 1
3	MSbyte of PARAMETERvalue 2	LSbyte of PARAMETERvalue 2
	.	.
	.	.
	.	.
N + 1	MSbyte of PARAMETERvalue N	LSbyte of PARAMETERvalue N

If the PARAMETERdata is numeric, it must be in 2's complement format. You do not shift and add “phasing” bits to the data.

The EXAMINE VALUE command must be issued to the pcBIRD in the following one word sequence:

WORD #	Most Significant Byte	Least Significant Byte
1	EXAMINE command = 4F Hex	PARAMETERnumber

The PARAMETERdata is returned as words. If the PARAMETERdata is numeric, it is in 2's complement format. The PARAMETERdata received does not contain “phasing” bits. The PARAMETERdata value, content and scaling depend on the particular parameter requested. For further explanation, see the following discussion of each parameter.

BIRD STATUS
PARAMETERnumber = 0

When PARAMETERnumber = 0, during EXAMINE, the pcBIRD returns a status word to tell the user in what mode the unit is operating. The bit assignments for the two byte response are as follows:

B15	1 if BIRD is a Master BIRD 0 if BIRD is a Slave BIRD
B14	1 if BIRD has been initialized (AUTO-CONFIGURED) 0 if BIRD has not been initialized
B13	1 if an error has been detected 0 if no error is detected
B12	1 if BIRD is RUNNING 0 if BIRD is not RUNNING
B11	1 if in HOST SYNC mode 0 if not in HOST SYNC mode
B10	1 if Expanded Address mode enabled 0 if Normal Address mode enabled Note: If you are in Super-Expanded Address mode, this command will still report that the Expanded Address mode is enabled and you will have to use the FBB Addressing Mode command to find out which Addressing mode is actually enabled.
B9	1 if in CRTSYNC mode 0 if not in CRTSYNC mode
B8	1 if no sync modes are enabled 0 if a sync mode is enabled
B7	1 if the factory test and pcBIRD commands are enabled 0 if only the pcBIRD commands are enabled
B6	0

B5	1 if the pcBIRD is in SLEEP mode. Same as B12 0 if the pcBIRD is in RUN mode
B4, B3, B2, B1	0001 if POSITION outputs selected 0010 if ANGLE outputs selected 0011 if MATRIX outputs selected 0100 if POSITION/ANGLE outputs selected 0101 if POSITION/MATRIX outputs selected 0110 factory use only 0111 if QUATERNION outputs selected 1000 if POSITION/QUATERNION outputs selected
B0	0 if POINT mode selected 1 if STREAM mode selected

SOFTWARE REVISION NUMBER
PARAMETERnumber = 1

When PARAMETERnumber = 1, during EXAMINE, the pcBIRD returns the revision number of the software located in the pcBIRD's PROM memory. The revision number in base 10 is expressed as INT.FRA where INT is the integer part of the revision number and FRA is the fractional part. For example, if the revision number is 2.13, then INT = 2 and FRA = 13. The value of the most significant byte returned is INT. The value of the least significant byte returned is FRA. Thus, in the above example, the value returned in the most significant byte would have been 02 Hex and the value of the least significant byte would have been 0D Hex. If the revision number were 3.1 then the bytes would be 03 and 01 Hex.

BIRD COMPUTER CRYSTAL SPEED
PARAMETERnumber = 2

When PARAMETERnumber = 2, during EXAMINE, the pcBIRD returns the speed of its computer's crystal in megahertz (MHz). You need to know the crystal speed if you want to determine or set the measurement rate of the pcBIRD or compute the vertical scan rate of your CRT. The most significant byte of the speed word is equal to zero, and the base 10 value of the least significant byte represents the speed of the crystal. For example, if the least significant byte = 19 Hex, the crystal speed is 25 MHz.

POSITION SCALING
PARAMETERnumber = 3

When PARAMETERnumber = 3, during EXAMINE, the pcBIRD returns a code that describes the scale factor used to compute the position of the sensor with respect to the transmitter. If the separation exceeds this scale factor, the pcBIRD's position outputs will not change to reflect this increased distance, rendering the measurements useless. The most significant byte of the parameter word returned is always zero. If the least significant byte = 0, the scale factor is 36 inches for a full scale position output. If the least significant byte is = 1, the full scale output is 72 inches. Do not use this command with the Extended Range Transmitter (ERT). Full scale output for the ERT is 144 inches and is not changeable.

To CHANGE the scale factor, send the pcBIRD two bytes of PARAMETERdata with the most significant byte set to zero and the least significant set to zero or one.

Note: Changing the scale factor from the default 36 inches to 72 inches reduces by half the resolution of the output X, Y, Z coordinates.

Regardless of the scale factor setting, operation of the pcBIRD at ranges beyond the specified 48-inch operating range is not recommended. At these increased ranges, the pcBIRD's outputs will exhibit increased noise and reduced dynamic response. If the increased noise is too great for your application, use the CHANGE VALUE command on the ALPHA_MIN filter parameter.

FILTER ON/OFF STATUS
PARAMETERnumber = 4

When PARAMETERnumber = 4, during EXAMINE, the pcBIRD returns a code telling you what software filters are turned on or off in the unit. The average user should not have to change the filters, but it is possible to do so. The most significant byte returned is always zero. The bits in the least significant byte are coded as follows:

BIT NUMBER	MEANING
B7-B3	0
B2	0 if the AC NARROW notch filter is ON 1 if the AC NARROW notch filter is OFF (default)
B1	0 if the AC WIDE notch filter is ON (default) 1 if the AC WIDE notch filter is OFF
B0	0 if the DC filter is ON (default) 1 if the DC filter is OFF

The AC NARROW notch filter refers to a two tap finite impulse response (FIR) notch filter applied to signals measured by the pcBIRD's sensor to eliminate a narrow band of noise with sinusoidal characteristics. Use this filter in place of the AC WIDE notch filter when you want to minimize the transport delay between pcBIRD’s measurement of the sensor's position/orientation and the output of these measurements. The transport delay of the AC NARROW notch filter is approximately one third the delay of the AC WIDE notch filter.

The AC WIDE notch filter refers to a six tap FIR notch filter applied to the sensor data to eliminate sinusoidal signals with a frequency between 30 and 72 hertz. If your application requires minimum transport delay between measurement of the sensor's position/orientation and the output of these measurements, you may want to evaluate the effect on your application of having this filter shut off and the AC NARROW notch filter on. If you are running the pcBIRD synchronized to a CRT, you can usually shut this filter off without experiencing an increase in noise.

Note: For optimal notch filter performance, make sure the pcBIRD is set for the proper Line Frequency by checking it with the FILTER LINE FREQUENCY command.

The DC filter refers to an adaptive, infinite impulse response (IIR) low pass filter applied to the sensor data to eliminate high frequency noise. Generally, this filter is always required in the system unless your application can work with noisy outputs. When the DC filter is turned on, you can modify its noise/lag characteristics by changing ALPHA_MIN and Vm.

To CHANGE the FILTER ON/OFF STATUS, send the pcBIRD two bytes of PARAMETERdata with the most significant byte set to zero and the least significant set to the code in the table above.

DC FILTER CONSTANT TABLE ALPHA_MIN
PARAMETERnumber = 5

When PARAMETERnumber = 5, during EXAMINE, the pcBIRD returns 7 words (14 bytes) which define the lower end of the adaptive range that filter constant ALPHA_MIN can assume in the DC filter as a function of sensor-to-transmitter separation. When ALPHA_MIN = 0 Hex, the DC filter will provide an infinite amount of filtering (the outputs will never change even if you move the sensor). When ALPHA_MIN = 0.99996 = 7FFF Hex, the DC filter will provide no filtering of the data.

The default values as a function of transmitter-to-sensor separation range for the Standard Range and Extended Range Transmitters are as follows:

Std. Range Xmtr Range (inches)	Extended Range Xmtr Range (inches)	ALPHA_MIN (decimal)
0 to 17	0 to 55	0.02 = 028F Hex.
17 to 22	55 to 70	0.02
22 to 27	70 to 90	0.02
27 to 34	90 to 110	0.02
34 to 42	110 to 138	0.02
42 to 54	138 to 170	0.02
54 +	170 +	0.02

To CHANGE ALPHA_MIN, send the pcBIRD seven words of PARAMETERdata corresponding to the ALPHA_MIN table defined above. At the shorter ranges, you may want to increase ALPHA_MIN to obtain less lag, while at longer ranges, you may want to decrease ALPHA_MIN to provide more filtering (less noise/more lag). If you decrease the value below 0.008, the output noise will actually increase due to loss of mathematical precision. ALPHA_MIN must always be less than ALPHA_MAX.

BIRD MEASUREMENT RATE COUNT
PARAMETERnumber = 6

When PARAMETERnumber = 6, during EXAMINE, the pcBIRD returns a word used to determine the measurement rate of the unit. The word returned represents a timer count (XMTR_TIME_CNT) determining how long each of the pcBIRD's three transmitter antennas will be turned on/off. From this word, you can estimate the total measurement period. XMTR_TIME_CNT is returned with values from 0000 to FFFF Hex or 0 to 65535 decimal. See the pcBIRD MEASUREMENT RATE command below for a simpler form of this command.

The measurement rate in cycles/sec is computed from:

measurement rate = 1000 / (4.0 * XTIME + 0.3)

where XTIME in milliseconds is:

XTIME = XMTR_TIME_CNT * CLOCK / 1000

where CLOCK is the period of one computer time count in microseconds. With a crystal value equal to 40 MHz, CLOCK = 8 / 40. The crystal value is determined by using the command EXAMINE VALUE BIRD COMPUTER CRYSTAL SPEED.

The pcBIRD's measurement rate is nominally set for 103.3 measurements/sec. If, however, the unit is synchronized to your CRT (see CRT SYNC command), the measurement rate will automatically increase. If you reduce the measurement rate after you are synchronized, the pcBIRD will drop out of synchronization. To regain synchronization, reissue the CRT SYNC command = 2. Increasing the rate will not cause loss of synchronization nor will it result in an increased measurement rate beyond the retrace rate of the CRT.

To CHANGE the MEASUREMENT RATE COUNT, send the pcBIRD one word of PARAMETERdata corresponding to XMTR_TIME_CNT defined above.

You can increase the pcBIRD's measurement rate to a maximum of 144 measurements/sec. The downside of going to rates faster than 103.3 measurements/sec is that the noise on your outputs may increase and any errors introduced by nearby metals will also increase.

You can decrease the pcBIRD's measurement rate to no less than 20 measurements/sec for 40 MHz BIRDs. At this value, XMTR_TIME_CNT reaches its maximum value of 65535. Decreasing the measurement rate is useful if you need to reduce errors resulting from highly conductive metals such as aluminum. If you have low-conductive, highly permeable metals in your environment such as carbon steel or iron, changing the measurement rate will not change the distortions. For low-conductive, low permeability metals such as 300 series stainless steel or nickel, speed changes will have minimal effect, since in this case, the metal is not introducing any errors into the pcBIRD's measurements anyway.

The downside of decreasing the pcBIRD's measurement rate is that dynamic performance is decreased. That is, if you move the pcBIRD's sensor quickly, the slow measurement rate will cause increased lag errors. Also, at slower rates, the noise will increase or decrease, depending on the rate you choose. For example, the noise will be at a maximum if you select a measurement rate equal to your power line frequency of 50 or 60 hertz.

As you change the pcBIRD's measurement rate, you may want to experiment with changing the filter characteristics. For example, the AC filter is optimized for a measurement rate of 103.3 measurements/sec. At very low measurement rates, you may want to shut this filter off.

BIRD MEASUREMENT RATE
PARAMETERnumber = 7

When PARAMETERnumber = 7, during EXAMINE, the pcBIRD returns a word used to determine the measurement rate of the unit. The word returned is the measurement rate in cycles/sec times 256.

The measurement rate in cycles/sec is computed from:

measurement rate = (word returned) / 256.

To CHANGE the MEASUREMENT RATE, send the pcBIRD one word of PARAMETERdata corresponding to (measurement rate) * 256.

The MEASUREMENT RATE command is a simpler form of the MEASUREMENT RATE COUNT command. Refer to the MEASUREMENT RATE COUNT command regarding speed limits and metal distortion verses noise tradeoffs.

DISABLE/ENABLE DATA READY OUTPUT
PARAMETERnumber = 8

Enabling the DATA READY character provides a method for notifying you as soon as the newest position and orientation data has been computed. Typically, you would issue a POINT data request as soon as you receive the DATA READY command. If you are running in STREAM mode you should not use the DATA READY character since the position and orientation is sent to you automatically as soon as it is ready.

When PARAMETERnumber = 8, during EXAMINE, the pcBIRD outputs one word of data equal to 1 if Data Ready Output is enabled or a 0 if disabled.

Caution: When using the EXAMINE command, if DATA READY is enabled, you may receive the DATA READY character itself followed by another word containing the 1, depending on when in the unit's computation cycle you issued the EXAMINE request. If you receive the DATA READY character first, read the next word containing the 1 to clear the output buffer.

To CHANGE DATA READY, send the pcBIRD one byte of PARAMETERdata = 1 if the pcBIRD is to output the Data Ready Character every measurement cycle as soon as a new measurement is ready for output. The default Data Ready Character is a comma (2C Hex, 44 Dec).

SET DATA READY CHARACTER
PARAMETERnumber = 9

When PARAMETERnumber = 9, during EXAMINE, the pcBIRD returns one word, the current Ascii value of the Data Ready Character in the LSbyte.

To CHANGE the DATA READY CHARACTER, send the pcBIRD one word of PARAMETERdata equal to the character value that the unit should use as the Data Ready Character in the LSbyte.

ERROR CODE
PARAMETERnumber = 10

When PARAMETERnumber = 10, during EXAMINE, the pcBIRD will output a one word Error register code, defined in the Error Message Section 11.0. The error code is reset to all zero's after it has been read.

ERROR DETECT MASK
PARAMETERnumber = 11

When PARAMETERnumber = 11, during EXAMINE, the pcBIRD returns one word which is the ERROR DETECT MASK. If ERROR DETECT MASK = 0, the pcBIRD, when it detects an error, will perform as defined in the Error Message Section 11.0. If ERROR DETECT MASK = 1, then FATAL errors which would stop the pcBIRD and blink the error code continuously only blink the message once and try to continue BIRD operation. If ERROR DETECT MASK = 3, error messages that are FATAL or WARNING1 level do not blink the error code at all and do not stop BIRD operation, but the Error register is updated.

To CHANGE the ERROR DETECT MASK send to the pcBIRD one byte of PARAMETERdata with a value of 0, 1 or 3 as defined above.

DC FILTER TABLE Vm
PARAMETERnumber = 12

When PARAMETERnumber = 12, during EXAMINE, the pcBIRD returns a 7 word table, or during CHANGE, the user sends to the pcBIRD a 7 word table representing the expected noise that the DC filter will measure. By changing the table values, the user can increase or decrease the DC filter's lag as a function of sensor range from the transmitter.

The DC filter is adaptive in that it tries to reduce the amount of low pass filtering in the pcBIRD as it detects translation or rotation rates in the unit's sensor. Reducing the amount of filtering results in less filter lag. Unfortunately, electrical noise in the environment, measured by the sensor also makes it look like the sensor is undergoing a translation and rotation. As the sensor moves farther and farther away from the transmitter, the amount of noise measured by the sensor appears to increase because the measured transmitted signal level is decreasing and the sensor amplifier gain is increasing. In order to decide if the amount of filtering should be reduced, the pcBIRD has to know if the measured rate is a real sensor rate due to movement or a false rate due to noise. The pcBIRD gets this knowledge by the user specifying what the expected noise levels are in the operating environment as a function of distance from the transmitter. These noise levels are the 7 words that form the Vm table. The Vm values can range from 1 for almost no noise to 32767 for a lot of noise.

The default values as a function of transmitter-to-sensor separation range for the standard range and extended range transmitters are as follows:

Std. Range Xmtr Range (inches)	Extended Range Xmtr Range (inches)	Vm (integer)
0 to 17	0 to 55	2
17 to 22	55 to 70	4
22 to 27	70 to 90	8
27 to 34	90 to 110	32
34 to 42	110 to 138	64
42 to 54	138 to 170	256
54 +	170 +	512

As Vm increases with range so does the amount of filter lag. To reduce the amount of lag, reduce the larger Vm values until the noise in the pcBIRD's output is too large for your application.

DC FILTER CONSTANT TABLE ALPHA_MAX
PARAMETERnumber = 13

When PARAMETERnumber = 13, during EXAMINE, the pcBIRD returns 7 words which define the upper end of the adaptive range that filter constant ALPHA_MAX can assume in the DC filter as a function of sensor-to-transmitter separation. When there is a fast motion of the sensor, the adaptive filter reduces the amount of filtering by increasing the ALPHA used in the filter. It will increase ALPHA only up to the limiting ALPHA_MAX value. By doing this, the lag in the filter is reduced during fast movements. When ALPHA_MAX = 0.99996 = 7FFF Hex, the DC filter will provide no filtering of the data during fast movements.

The default values as a function of transmitter to sensor separation range for the standard range and extended range transmitters are as follows:

Std. Range Xmtr Range (inches)	Extended Range Xmtr Range (inches)	ALPHA_MAX (fractional)
0 to 17	0 to 55	0.9 = 07333 Hex.
17 to 22	55 to 70	0.9
22 to 27	70 to 90	0.9
27 to 34	90 to 110	0.9
34 to 42	110 to 138	0.9
42 to 54	138 to 170	0.9
54 +	170 +	0.9

To CHANGE ALPHA_MAX, send the pcBIRD seven words of PARAMETERdata corresponding to ALPHA_MAX. During CHANGE, you may want to decrease ALPHA_MAX to increase the amount of filtering if the unit's outputs are too noisy during rapid sensor movement. ALPHA_MAX must always be greater than ALPHA_MIN.

SUDDEN OUTPUT CHANGE LOCK
PARAMETERnumber = 14

When PARAMETERnumber = 14, during EXAMINE, the pcBIRD returns a word which indicates if the position and orientation outputs will be allowed to change if the system detects a sudden large change in the outputs. Large undesirable changes may occur at large separation distances between the transmitter and sensor when the sensor undergoes a fast rotation or translation. The word returned will = 1 to indicate that the outputs will not be updated if a large change is detected. If the byte returned is zero, the outputs will change.

To change SUDDEN OUTPUT CHANGE LOCK, send the pcBIRD one word of PARAMETERdata = 0 to unlock the outputs or send one byte = 1 to lock the outputs.

SYSTEM MODEL IDENTIFICATION
PARAMETERnumber = 15

When PARAMETERnumber = 15, during EXAMINE, the pcBIRD returns 10 bytes which will represent the device that was found.

Device Description String	Device
“6DFOB ”	Stand alone (SRT)
“6DERC ”	Extended Range Controller
“6DBOF ”	MotionStar (old name)
“6DMIN ”	miniBIRD
“MINIBIRD2 ”	miniBIRD-II with 1 Xmtr and 1 Snsr
“MINIBIRD2R”	miniBIRD-II with 1 Xmtr and 2 Snsrs
“MINIBIRD2X”	miniBIRD-II with 2 Xmtrs and 2 Snsrs
“PCBIRD ”	pcBIRD
“SPACEPAD ”	SpacePad
“MOTIONSTAR”	MotionStar (new name)
“WIRELESS ”	MotionStar Wireless

EXPANDED ERROR CODE
PARAMETERnumber = 16

When PARAMETERnumber = 16, during EXAMINE, the pcBIRD will output one word describing the error code with expanded error information. The first byte output is the Error register code as defined in examine value with PARAMETERnumber = 10 and the second byte is the expanded error code information which is additional information describing why the error occurred.

Expanded error information is only useful when the first byte, the error code, is 13 (No FBB Command Response). When in Normal Addressing mode, the least significant 4 bits of the second byte contain the address (1 through 14) of the Slave which did not respond to the Master. When in Expanded Addressing mode, the least significant 5 bits contain the address (1 through 30) of the Slave which did not respond to the Master. The remaining most significant bits contain factory diagnostic information and should be ignored. When in Super-Expanded Addressing, mode the least significant 7 bits contain the address (1 through 126) of the Slave which did not respond to the Master.

XYZ REFERENCE FRAME
PARAMETERnumber = 17

By default, the XYZ measurement frame is the reference frame defined by the physical orientation of the transmitter's XYZ axes even when the REFERENCE FRAME command has been used to specify a new reference frame for measuring orientation angles. When PARAMETERnumber = 17, during CHANGE, if the one byte of PARAMETER DATA sent to the pcBIRD is = 1 then the XYZ measurement frame will also correspond to the new reference frame defined by the REFERENCE FRAME command. When the PARAMETER DATA sent is a zero, the XYZ measurement frame reverts to the orientation of the transmitter's physical XYZ axes.

During EXAMINE, the pcBIRD returns a byte value of 0 or 1 to indicate that the XYZ measurement frame is either the transmitter's physical axes or the frame specified by the REFERENCE FRAME command.

TRANSMITTER OPERATION MODE
PARAMETERnumber = 18

When PARAMETERnumber = 18, during EXAMINE, the pcBIRD returns a word that is used to determine the current Transmitter Mode. The value of the LSbyte returned may take one of the following valid values: (This value is contained in the least significant 7 bits of the byte.)

0	Non-Pulsed mode
1	Pulsed mode
2	"Cool-Down" mode

Some waveforms cannot be used with some Flock components, so care must be taken if this command is used.

Note: The miniBIRD and miniBIRD-II transmitter circuits cannot operate in Non-Pulsed mode. Running the Non-Pulsed mode on the miniBIRD and miniBIRD-II will immediately destroy the transmitter drive circuits. The miniBIRD and miniBIRD-II automatically default to the "Cool-Down" mode and may be run in the Pulsed mode. The miniBIRD and miniBIRD-II as FBB Master will ignore the Non-Pulsed mode command.

Note: The pcBIRD transmitter circuits cannot operate in Non-Pulsed mode. Running the Non-Pulsed mode on the pcBIRD over a long period of time will damage the transmitter drive circuits. The pcBIRD automatically defaults to the "Cool-Down" mode and may be run in the Pulsed mode. The pcBIRD as the FBB Master will ignore the Non-Pulsed mode command.

All ERC components may be run in Non-Pulsed mode.

To CHANGE the current transmitter mode send the pcBIRD one word of PARAMETERdata corresponding to the codes described above.

Note: This command must be sent to every BIRD in the Flock.

Note: The Pulsed mode offers better dynamic performance. The Non-Pulsed mode offers better resistance to metal distortion.

FBB ADDRESSING MODE
PARAMETERnumber = 19

When PARAMETERnumber = 19, during EXAMINE, the pcBIRD returns a word that contains a value in the LSbyte which defines the current FBB addressing mode. The following are the valid values for the addressing mode:

0	NORMAL	(FBB address range = 1 -> 14)
1	EXPANDED	(FBB address range = 1 -> 30)
3	SUPER-EXPANDED	(FBB address range = 1 -> 126)

This parameter cannot be CHANGED.

FILTER LINE FREQUENCY
PARAMETERnumber = 20

When PARAMETERnumber = 20, during EXAMINE, the pcBIRD returns a word whose value in the LSbyte is the Line Frequency which is being used to determine the Wide Notch Filter coefficients. The default Line Frequency is 60 Hz.

To CHANGE the Line Frequency, send 1 byte of PARAMETERdata corresponding to the desired Line Frequency. The range of Line Frequencies available are 1 -> 255.

Example: To change the Line Frequency to 50Hz, you would first send a Change Value command (50 Hex), followed by a Filter Line Frequency command (14 Hex), followed by the line frequency for 50 Hz (32 Hex).

FBB ADDRESS
PARAMETERnumber = 21

When PARAMETERnumber = 21, during EXAMINE, the pcBIRD will return one word corresponding to its current FBB address. This is useful when communicating to the Flock through multiple RS232 interfaces or through the ISA Bus.

This parameter cannot be CHANGED.

CHANGE/EXAMINE HEMISPHERE
PARAMETERnumber = 22

When PARAMETERnumber = 22, during EXAMINE, the pcBIRD will return one word of data defining the current Hemisphere. These are as follows:

Hemisphere	HEMI_AXIS		HEMI_SIGN	
	ASCII	HEX	ASCII	HEX
Forward	nul	00	nul	00
Aft (Rear)	nul	00	soh	01
Lower	ff	0C	nul	00
Upper	ff	0C	soh	01
Right	ack	06	nul	00
Left	ack	06	soh	01

Note: These are the same PARAMETERdata values as are used by the HEMISPHERE command 'L' (4C Hex).

To CHANGE the Hemisphere, send 2 PARAMETERdata bytes as described above.

Note: This command operates in exactly the same way as the HEMISPHERE command. The command is included in the CHANGE/EXAMINE command set in order to allow users to examine the values which were previously inaccessible.

Note: The values can only be EXAMINED with this command if they were previously CHANGED by this command.

CHANGE/EXAMINE ANGLE ALIGN2
PARAMETERnumber = 23

When PARAMETERnumber = 23, during EXAMINE, the pcBIRD will return 3 words of data corresponding to the Azimuth, Elevation, and Roll angles used in the ANGLE ALIGN2 command. This command differs from the ANGLE ALIGN2 command only in that it allows both reading and writing of the angles. See ANGLE ALIGN2 for a full explanation of it’s use.

To CHANGE the angles, send 6 bytes of PARAMETERdata after the 2 command bytes.

Note: The angles can only be read back with this command if they were previously written with this command, i.e. if the ANGLE ALIGN2 (or the ANGLE ALIGN) was used to set the angles, those angles will not be accessible with the EXAMINE ANGLE ALIGN2 command.

CHANGE/EXAMINE REFERENCE FRAME2
PARAMETERnumber = 24

When PARAMETERnumber = 24, during EXAMINE, the pcBIRD will return 3 words of data corresponding to the Azimuth, Elevation and Roll angles used in the REFERENCE FRAME2 command.

See REFERENCE FRAME2 command for further explanation.

To CHANGE the angles, send 6 bytes of PARAMETERdata after the 2 command bytes.

Note: These angles are only accessible with this command if they were previously written with this command.

BIRD SERIAL NUMBER
PARAMETERnumber = 25

When PARAMETERnumber = 25, during EXAMINE, the pcBIRD will return a 1 word value corresponding to the Serial Number of the pcBIRD electronic unit.

Note: This number cannot be changed.

SENSOR SERIAL NUMBER
PARAMETERnumber = 26

When PARAMETERnumber = 26, during EXAMINE, the pcBIRD will return a 1 word value corresponding to the Serial Number of the pcBIRD's sensor. You can not swap sensors while the pcBIRD is running If you do, you will get the Serial Number of the sensor that was attached to the unit when it was first turned on.

Note: This number cannot be changed.

XMTR SERIAL NUMBER
PARAMETERnumber = 27

When PARAMETERnumber = 27, during EXAMINE, the pcBIRD will return a 1 word value corresponding to the Serial Number of the pcBIRD's transmitter. You can not swap transmitters while the pcBIRD is running. If you do, you will get the Serial Number of the transmitter that was attached to the unit when it was first turned on.

Note: This number cannot be changed.

GROUP MODE
PARAMETERnumber = 35

The GROUP MODE command is only used if you have multiple BIRDs working together in a Master/Slave configuration and you want to get data from all the BIRDs by talking to only the Master BIRD.

When PARAMETERnumber = 35, during EXAMINE VALUE, the pcBIRD will respond with one word of data indicating if the unit is in GROUP MODE. If the data is a 1, the pcBIRD is in GROUP MODE and if the data is 0, the pcBIRD is not in GROUP MODE. When in GROUP MODE, in response to the POINT or STREAM commands, the Master BIRD will send data records from all running BIRDs with sensors residing on the FBB. Information is output from the BIRD with the smallest address first. The last word of the data record from each BIRD contains the address of that BIRD. This address word contains no "phasing" bits. Each BIRD can be in a different data output format if desired. For example, if 3 units are in the Flock, and the first is configured to output POSITION data only (3 data words plus 1 address word) and the other two are configured to output POSITION/ANGLES data (6 data words plus 1 address word), the Master BIRD will respond with 18 words when a data request is made.

During a CHANGE VALUE command, the host must send one data word equal to a 1 to enable GROUP MODE or a 0 to disable GROUP MODE.

FLOCK SYSTEM STATUS
PARAMETERnumber = 36

When PARAMETERnumber = 36, during EXAMINE, the Master BIRD returns to the host computer 7 words (15 words if in Expanded Address mode, 63 words if in Super-Expanded Address mode) defining the physical configuration of each BIRD on the bus. This command can be sent to the Master either before or after the Flock is running. The response has the following format, where one byte is returned for each possible FBB address:

WORD #	Most Significant Byte	Least Significant Byte
1	address 1 configuration	address 2 configuration
2	address 3 configuration	address 4 configuration
	.	.
	.	.
	.	.
7 (15/63)	address 13 (29/125) config	address 14 (30/126) config

Each byte has the following format:

BIT 7	If 1, device is accessible on FBB. If 0, device is not accessible. A device is accessible when it has power on. It may or may not be running.
BIT 6	If 1, device is running. If 0, device is not running. A device is running when the power switch is on, it has been AUTO-CONFIGed and it is AWAKE. A device is not running when the power switch is on and it has not been AUTO-CONFIGed or it has been AUTO-CONFIGed and it is ASLEEP.
BIT 5	If 1, device has a sensor. If 0, device does not have a sensor.
BIT 4	If 1, transmitter is an ERT. If 0, transmitter is standard range.
BIT 3	If 1, ERT #3 is present. If 0, ERT #3 is not present.
BIT 2	If 1, ERT #2 is present. If 0, ERT #2 is not present.
BIT 1	If 1, ERT #1 is present. If 0, ERT #1 is not present.
BIT 0	If 1, ERT #0 or standard range transmitter is present. If 0, ERT #0 is not present.

FBB AUTO-CONFIGURATION
PARAMETERnumber = 50

The AUTO-CONFIGURATION command is used to start running multiple BIRDs working together in a Master/Slave configuration or a single BIRD with an Extended Range Transmitter.

When PARAMETERnumber = 50, during an CHANGE VALUE command, the Master BIRD will perform all the necessary configurations of the Slaves and itself for a one transmitter/multiple sensor configuration. The Master BIRD expects one word of data corresponding to the number of BIRD electronic units on the FBB that should be used in the 1 transmitter/multiple sensor mode. For example, if the one word = 3 then the BIRD at address = 1 (the default Master) will assume that there are also BIRDs at addresses 2 and 3. These three BIRD units will then start running. If you have an Extended Range Transmitter Controller (ERC) in your configuration, the ERC counts as one BIRD electronics unit. Note that contiguous addresses must be used (i.e., for 1 transmitter 5 sensors, BIRDs with addresses 1 through 5 must be present). The command sequence would look like this in Hex:

WORD #	Most Significant Byte	Least Significant Byte
1	50	32
2	0	3

Once the Flock is running, the AUTO-CONFIGURATION command can also be used to reconfigure a Flock. For example, if the Flock is currently AUTO-CONFIGURED with 3 BIRD units, you can reconfigure it with 2 BIRD units by sending the AUTO-CONFIGURATION command with 2 as the data while the Flock is in operation.

Resending AUTO-CONFIGURATION to the Master after an error develops in the Flock will many times clear the error and restart the system.

If you have GROUP STREAM mode running, you must first terminate STREAM mode before sending another AUTO-CONFIGURATION command.

Before sending the AUTO-CONFIGURATION command, you must wait at least 600 milliseconds to allow any previous commands to complete. After sending the AUTO-CONFIGURATION command you must also wait at least 600 milliseconds before sending another command.

FBB RESET **FBB RESET**

	ASCII	HEX	DECIMAL	BINARY
Command Byte	/	2F	47	00101111

This command sent to the Master on the FBB will cause all of the Slaves to be reset through the FBB. A typical initialization procedure would be as follows:

Do a hardware reset of the Master by toggling the RTS line on the RS232 interface to the Master. After the Master has been reset and is running, issue this FBB RESET command to the Master and the Master will reset all of the Slaves through the FBB.

Note: The Reset Jumper (jumper 3 on the pcBIRD, jumper 11 on the ERC) must be in place on all of the Slaves but not on the Master BIRD in order for this command to work.

HEMISPHERE **HEMISPHERE**

	ASCII	HEX	DECIMAL	BINARY
Command Byte	L	4C	76	01001100

Command Data	HEMI_AXIS	HEMI_SIGN

The shape of the magnetic field transmitted by the pcBIRD is symmetrical about each of the axes of the transmitter. This symmetry leads to an ambiguity in determining the sensor's X, Y, Z position. The amplitudes will always be correct, but the signs (±) may all be wrong, depending upon the hemisphere of operation. In many applications, this will not be relevant, but if you desire an unambiguous position measurement, operation must be either confined to a defined hemisphere or your host computer must 'track' the location of the sensor.

There is no ambiguity in the sensor's orientation angles as output by the ANGLES command, or in the rotation matrix as output by the MATRIX command.

The HEMISPHERE command is used to tell the pcBIRD in which hemisphere, centered about the transmitter, the sensor will be operating. There are six hemispheres from which you may choose: the forward, aft (rear), upper, lower, left, and right. If no HEMISPHERE command is issued, the forward is used by default.

The two Command Data bytes, sent immediately after the HEMISPHERE command, are to be selected from the following:

Hemisphere	HEMI_AXIS		HEMI_SIGN	
	ASCII	HEX	ASCII	HEX
Forward	nul	00	nul	00
Aft (Rear)	nul	00	soh	01
Upper	ff	0C	soh	01
Lower	ff	0C	nul	00
Left	ack	06	soh	01
Right	ack	06	nul	00

The HEMISPHERE command sequence sent to each BIRD with a receiver would look like this:

WORD #	Most Significant Byte	Least Significant Byte
1	command = 4C	HEMI_AXIS
2	HEMI_SIGN	0

The ambiguity in determining position can be eliminated if your host computer's software continuously 'tracks' the sensor location. In order to implement tracking, you must understand the behavior of the signs (±) of the X, Y, and Z position outputs when the sensor crosses a hemisphere boundary. When you select a given hemisphere of operation, the sign on the position axes that defines the hemisphere direction is forced to positive, even when the sensor moves into another hemisphere. For example, the power-up default hemisphere is the forward hemisphere. This forces X position outputs to always be positive. The signs on Y and Z will vary between plus and minus depending on where you are within this hemisphere. If you had selected the lower hemisphere, the sign of Z would always be positive and the signs on X and Y would vary between plus and minus. If you had selected the left hemisphere, the sign of Y would always be negative, etc.

If the sensor moved into the aft hemisphere while using the default forward hemisphere, the signs on Y and Z would instantaneously change to opposite polarities while the sign on X remained positive. To 'track' the sensor, your host software, on detecting this sign change, would reverse the signs on the pcBIRD's X, Y, and Z outputs. In order to 'track' correctly, you must start 'tracking' in the selected hemisphere, so the signs on the outputs are initially correct, and you must guard against having the sensor legally cross the Y = 0, Z = 0 axes simultaneously without having crossed the X = 0 axes into the other hemisphere.

MATRIX **MATRIX**

	ASCII	HEX	DECIMAL	BINARY
Command Byte	X	58	88	01011000

The MATRIX mode outputs the 9 elements of the rotation matrix that define the orientation of the sensor's X, Y, and Z axes with respect to the transmitter's X, Y, and Z axes. If you want a three-dimensional image to follow the rotation of the sensor, you must multiply your image coordinates by this output matrix.

The nine elements of the output matrix are defined generically by the following:

```
*                                                   *
*         M(1,1)            M(1,2)          M(1,3)  *
*                                                   *
*                                                   *
*         M(2,1)            M(2,2)          M(2,3)  *
*                                                   *
*                                                   *
*         M(3,1)            M(3,2)          M(3,3)  *
*                                                   *
```

Or, in terms of the rotation angles about each axis
where Z = Zang, Y = Yang and X = Xang...

```
*                                                   *
* COS(Y)*COS(Z)          COS(Y)*SIN(Z)        -SIN(Y)  *
*                                                   *
*                                                   *
*-COS(X)*SIN(Z)          COS(X)*COS(Z)               *
*+SIN(X)*SIN(Y)*COS(Z)  +SIN(X)*SIN(Y)*SIN(Z)  SIN(X)*COS(Y)*
*                                                   *
*                                                   *
* SIN(X)*SIN(Z)          -SIN(X)*COS(Z)              *
*+COS(X)*SIN(Y)*COS(Z)  +COS(X)*SIN(Y)*SIN(Z)  COS(X)*COS(Y)*
*                                                   *
```

Or in Euler angle notation, where R = Roll, E = Elevation, A = Azimuth...

```
*                                                                      *
* COS(E)*COS(A)             COS(E)*SIN(A)           -SIN(E)          *
*                                                                      *
*                                                                      *
*-COS(R)*SIN(A)             COS(R)*COS(A)                             *
*+SIN(R)*SIN(E)*COS(A)    +SIN(R)*SIN(E)*SIN(A)    SIN(R)*COS(E)*
*                                                                      *
*                                                                      *
* SIN(R)*SIN(A)            -SIN(R)*COS(A)                            *
*+COS(R)*SIN(E)*COS(A)    +COS(R)*SIN(E)*SIN(A)    COS(R)*COS(E)*
*                                                                      *
```

The 9 word output record is in the following order:

```
MSB                                                             LSB
 15   14   13   12   11   10   9   8   7   6   5   4   3   2   1   0

M15  M14  M13  M12  M11  M10  M9  M8  M7  M6  M5  M4  M3  M2  M1   1      M(1,1)
M15  M14  M13  M12  M11  M10  M9  M8  M7  M6  M5  M4  M3  M2  M1   0      M(2,1)
M15  M14  M13  M12  M11  M10  M9  M8  M7  M6  M5  M4  M3  M2  M1   0      M(3,1)

M15  M14  M13  M12  M11  M10  M9  M8  M7  M6  M5  M4  M3  M2  M1   0      M(1,2)
M15  M14  M13  M12  M11  M10  M9  M8  M7  M6  M5  M4  M3  M2  M1   0      M(2,2)
M15  M14  M13  M12  M11  M10  M9  M8  M7  M6  M5  M4  M3  M2  M1   0      M(3,2)

M15  M14  M13  M12  M11  M10  M9  M8  M7  M6  M5  M4  M3  M2  M1   0      M(1,3)
M15  M14  M13  M12  M11  M10  M9  M8  M7  M6  M5  M4  M3  M2  M1   0      M(2,3)
M15  M14  M13  M12  M11  M10  M9  M8  M7  M6  M5  M4  M3  M2  M1   0      M(3,3)
```

The matrix elements take values between the binary equivalents of +.99996 and -1.0. Element scaling is +.99996 = 7FFF Hex, 0 = 0 Hex, and -1.0 = 8000 Hex.

Matrix information is 0 when sensor saturation occurs in Expanded Addressing mode or Super-Expanded Addressing mode.

NEXT TRANSMITTER **NEXT TRANSMITTER**

	HEX	DECIMAL	BINARY
Command Byte	30	48	00110000

Command Data	TRANSMITTER ADDR and TRANSMITTER NUM

If you have multiple transmitters in your Flock and you want to turn on a transmitter other than the transmitter at FBB address 1, use the NEXT TRANSMITTER command. This command is sent to the current Master with a single byte of command data containing the FBB address (1 to 14) and the transmitter number (0 to 3) of the next transmitter you want to turn on. The transmitter number for the standard three foot operating range Flock transmitter is always 0. The transmitter number for the optional Extended Range Controller (ERC) can be 0, 1, 2 or 3 depending on which of the four transmitters is being used on the ERC. At the end of its current measurement cycle (1 to 10 milliseconds after the command is received), the addressed BIRD starts its transmitter.

Next Transmitter command data format:

```
MSB                                   LSB
7    6    5    4    3    2    1    0
A3   A2   A1   A0   0    0    N1   N0
```

where A3-A0 is the FBB address of the Next Transmitter,

```
A3  A2  A1  A0
 0   0   0   1   - Address 1
 0   0   1   0   - Address 2
       .
       .
       .
 1   1   1   0   - Address 14
```

and N1-N0 is the number of the NEXT TRANSMITTER at the FBB address,

N1	N0	
0	0	- Number 0
0	1	- Number 1
1	0	- Number 2
1	1	- Number 3

Therefore, to turn on the transmitter 2 at FBB address = 6, the command byte is 30H followed by a command data byte of 62H.

Notes:

1) With multiple transmitters, the measurement reference frame is defined with respect to the location and orientation of the transmitter that is currently turned on. Thus, unless each transmitter is aligned perfectly to each other, you will get a jump in the measured orientation of the sensor when the next transmitter is turned on. To overcome the angular misalignments, you can use the REFERENCE FRAME command directed to each transmitter after you power up the Flock but before you do the transmitter switching.

2) If you select a transmitter that is not available, then the Master will indicate Error 29, ‘Transmitter not Accessible'.

OUTPUT BUFFER CLEAR **OUTPUT BUFFER CLEAR**

	ASCII	HEX	DECIMAL	BINARY
Command Byte	f	66	102	01100110

The OUTPUT BUFFER CLEAR command stops any data that is in the process of being output and clears any data in the output buffers. If STREAM mode is enabled, this command disables STREAM mode.

To use the OUTPUT BUFFER CLEAR command:

1. Send the command.

2. Wait for the TDR bit to go high in the port at Base Address+2. This wait may be as long as 20 microseconds.

3. Read one word from the input port at Base Address+0 and throw the word away to clear the port. In reading this word you do not have to wait for the RDR bit to go high. This is the only command where you do not have to wait for the RDR bit to go high before reading a port.

The pcBIRD is now ready to accept new commands from the user.

Note: This is an ISA command only.

POINT **POINT**

	ASCII	HEX	DECIMAL	BINARY
Command Byte	B	42	66	01000010

In the POINT mode, the pcBIRD sends one data record each time it receives the B Command Byte. When in GROUP MODE, the Master BIRD will output a record for each running BIRD in the Flock (see EXAMINE/CHANGE parameter number 35). Remember, when GROUP MODE is enabled, an extra byte containing the FBB address of the pcBIRD is added to the end of each data record.

If you issue the POINT command immediately after you have changed the output format with an ANGLES, MATRIX, etc. command, you will receive zero's for the data in the new format for up to 8 milliseconds.

POSITION **POSITION**

	ASCII	HEX	DECIMAL	BINARY
Command Byte	V	56	86	01010110

In the POSITION mode, the pcBIRD outputs the X, Y, and Z positional coordinates of the sensor with respect to the transmitter. The output record is in the following format for the three transmitted words:

```
MSB                                                                 LSB
 15   14   13   12   11   10   9   8   7   6   5   4   3   2   1   0

X15  X14  X13  X12  X11  X10  X9  X8  X7  X6  X5  X4  X3  X2  X1   1      X
Y15  Y14  Y13  Y12  Y11  Y10  Y9  Y8  Y7  Y6  Y5  Y4  Y3  Y2  Y1   0      Y
Z15  Z14  Z13  Z12  Z11  Z10  Z9  Z8  Z7  Z6  Z5  Z4  Z3  Z2  Z1   0      Z
```

The X, Y, and Z values vary between the binary equivalent of ± MAX inches, where MAX = 36" or 72" if using a Standard Range Transmitter or MAX = 144" if using an Extended Range Transmitter. The positive X, Y, and Z directions are shown in Figure 5.

Scaling of each position coordinate is full scale = MAX inches. That is, +MAX = 7FFF Hex, 0 = 0 Hex, -MAX = 8000 Hex. Since the maximum range (Range = square root(X**2+Y**2+Z**2)) from the transmitter to the sensor is limited to MAX inches, only one of the X, Y, or Z coordinates may reach its full scale value. Once a full scale value is reached, the positional coordinates no longer reflect the correct position of the sensor.

To convert the numbers into inches, first cast it into a signed integer. This will give you a number from +/- 32767. Second, multiply by 36 or 72 if using a Standard Range Transmitter or 144 if using an Extended Range Transmitter. Finally, divide the number by 32767 to get the position in inches. The equation should look something like this:

Standard Range Transmitter: (signed int(Hex #) * 36) / 32767
Standard Range Transmitter: (signed int(Hex #) * 72) / 32767
Extended Range Transmitter: (signed int(Hex #) * 144) / 32767

POSITION/ANGLES POSITION/ANGLES

	ASCII	HEX	DECIMAL	BINARY
Command Byte	Y	59	89	01011001

In the POSITION/ANGLES mode, the outputs from the POSITION and ANGLES modes are combined into one record containing the following six words:

```
MSB                                                                 LSB
 15   14   13   12   11   10   9   8   7   6   5   4   3   2   1   0

X15  X14  X13  X12  X11  X10  X9  X8  X7  X6  X5  X4  X3  X2  X1   1      X
Y15  Y14  Y13  Y12  Y11  Y10  Y9  Y8  Y7  Y6  Y5  Y4  Y3  Y2  Y1   0      Y
Z15  Z14  Z13  Z12  Z11  Z10  Z9  Z8  Z7  Z6  Z5  Z4  Z3  Z2  Z1   0      Z

Z15  Z14  Z13  Z12  Z11  Z10  Z9  Z8  Z7  Z6  Z5  Z4  Z3  Z2  Z1   0      Zang
Y15  Y14  Y13  Y12  Y11  Y10  Y9  Y8  Y7  Y6  Y5  Y4  Y3  Y2  Y1   0      Yang
X15  X14  X13  X12  X11  X10  X9  X8  X7  X6  X5  X4  X3  X2  X1   0      Xang
```

See POSITION mode and ANGLE mode for number ranges and scaling.

POSITION/MATRIX **POSITION/MATRIX**

	ASCII	HEX	DECIMAL	BINARY
Command Byte	Z	5A	90	01011010

In the POSITION/MATRIX mode, the outputs from the POSITION and MATRIX modes are combined into one record containing the following twelve words:

```
MSB                                                                   LSB
 15   14   13   12   11   10   9   8   7   6   5   4   3   2   1   0

X15  X14  X13  X12  X11  X10  X9  X8  X7  X6  X5  X4  X3  X2  X1   1      X
Y15  Y14  Y13  Y12  Y11  Y10  Y9  Y8  Y7  Y6  Y5  Y4  Y3  Y2  Y1   0      Y
Z15  Z14  Z13  Z12  Z11  Z10  Z9  Z8  Z7  Z6  Z5  Z4  Z3  Z2  Z1   0      Z

M15  M14  M13  M12  M11  M10  M9  M8  M7  M6  M5  M4  M3  M2  M1   0      M(1,1)
M15  M14  M13  M12  M11  M10  M9  M8  M7  M6  M5  M4  M3  M2  M1   0      M(2,1)
M15  M14  M13  M12  M11  M10  M9  M8  M7  M6  M5  M4  M3  M2  M1   0      M(3,1)

M15  M14  M13  M12  M11  M10  M9  M8  M7  M6  M5  M4  M3  M2  M1   0      M(1,2)
M15  M14  M13  M12  M11  M10  M9  M8  M7  M6  M5  M4  M3  M2  M1   0      M(2,2)
M15  M14  M13  M12  M11  M10  M9  M8  M7  M6  M5  M4  M3  M2  M1   0      M(3,2)

M15  M14  M13  M12  M11  M10  M9  M8  M7  M6  M5  M4  M3  M2  M1   0      M(1,3)
M15  M14  M13  M12  M11  M10  M9  M8  M7  M6  M5  M4  M3  M2  M1   0      M(2,3)
M15  M14  M13  M12  M11  M10  M9  M8  M7  M6  M5  M4  M3  M2  M1   0      M(3,3)
```

See POSITION mode and MATRIX mode for number ranges and scaling.

POSITION/QUATERNION **POSITION/QUATERNION**

	ASCII	HEX	DECIMAL	BINARY
Command Byte	]	5D	93	01011101

In the POSITION/QUATERNION mode, the pcBIRD outputs the X, Y, and Z position and the four quaternion parameters, q_0, q_1, q_2, and q_3 which describe the orientation of the sensor with respect to the transmitter. The output record is in the following format for the seven transmitted words:

MSB 15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	LSB 0	
X15	X14	X13	X12	X11	X10	X9	X8	X7	X6	X5	X4	X3	X2	X1	1	X
Y15	Y14	Y13	Y12	Y11	Y10	Y9	Y8	Y7	Y6	Y5	Y4	Y3	Y2	Y1	0	Y
Z15	Z14	Z13	Z12	Z11	Z10	Z9	Z8	Z7	Z6	Z5	Z4	Z3	Z2	Z1	0	Z
B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	0	q_0
B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	0	q_1
B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	0	q_2
B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	0	q_3

See POSITION mode and QUATERNION mode for number ranges and scaling.

QUATERNION QUATERNION

	ASCII	HEX	DECIMAL	BINARY
Command Byte	\	5C	92	01011100

In the QUATERNION mode, the pcBIRD outputs the four quaternion parameters that describe the orientation of the sensor with respect to the transmitter. The quaternions, q_0, q_1, q_2, and q_3 where q_0 is the scalar component, have been extracted from the MATRIX output using the algorithm described in "Quaternion from Rotation Matrix" by Stanley W. Shepperd, Journal of Guidance and Control, Vol. 1, May-June 1978, pp. 223-4. The output record is in the following format for the eight transmitted bytes:

MSB															LSB	
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	1	q_0
B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	0	q_1
B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	0	q_2
B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	0	q_3

Scaling of the quaternions is full scale = +.99996 = 7FFF Hex, 0 = 0 Hex, and -1.0 = 8000 Hex.

REFERENCE FRAME1 **REFERENCE FRAME1**

	ASCII	HEX	DECIMAL	BINARY
Command Byte	H	48	72	01001000

Command Data	Sin(A)	Cos(A)	Sin(E)	Cos(E)	Sin(R)	Cos(R)

By default, the pcBIRD's reference frame is defined by the transmitter's physical X, Y, and Z axes. In some applications, it may be desirable to have the orientation measured with respect to another reference frame. The REFERENCE FRAME command permits you to define a new reference frame by inputting the angles required to align the physical axes of the transmitter to the X, Y, and Z axes of the new reference frame. The alignment angles are defined as rotations about the Z, Y, and X axes of the transmitter. These angles are called the, Azimuth, Elevation, and Roll angles.

The command sequence consists of a Command Byte and 12 Command Data bytes. The Command Data consists of the sines and cosines of the alignment angles Azimuth (A), Elevation (E), and Roll (R). See the REFERENCE FRAME2 command if you want to send only the angles and not the sines and cosines of the angles.

Although the REFERENCE FRAME1 command will cause the pcBIRD's output angles to change, it has no effect on the position outputs. If you want the unit’s XYZ position reference frame to also change with this command, you must first use the EXAMINE/CHANGE VALUE XYZ REFERENCE FRAME command.

If you immediately follow the REFERENCE FRAME1 command with a POINT or STREAM mode data request, you may not see the effect of this command in the data returned. It will take at least one measurement period (i.e. 10 milliseconds if running the pcBIRD at 100 measurements/sec) before you see the effect of the command.

If the command is sent to the Master, all accessible BIRDs in the Flock are updated. If the command is sent to the Slave, only the Slave is updated.

The sequence of output words to the pcBIRD takes the following form:

WORD #	Most Significant Byte	Least Significant Byte
1	REF command = 48	MSbyte SIN(A)
2	LSbyte SIN(A)	MSbyte COS(A)
3	LSbyte COS(A)	MSbyte SIN(E)
4	LSbyte SIN(E)	MSbyte COS(E)
5	LSbyte COS(E)	MSbyte SIN(R)
6	LSbyte SIN(R)	MSbyte COS(R)
7	LSbyte COS(R)	0

The sine and cosine elements take values between the binary equivalents of +.99996 and -1.0.

Element scaling is +.99996 = 7FFF Hex, 0 = 0 Hex, and -1.0 = 8000 Hex.

REFERENCE FRAME2 **REFERENCE FRAME2**

	ASCII	HEX	DECIMAL	BINARY
Command Byte	r	72	114	01110010

Command Data	A, E, R

This is the same as the REFERENCE FRAME1 command except that the command data consists of the angles only and not the sines and cosines of the angles.

The Command Byte and Command Data must be transmitted to the pcBIRD in the following four word format:

WORD #	Most Significant Byte	Least Significant Byte
1	REF command = 72	MSbyte A
2	LSbyte A	MSbyte E
3	LSbyte E	MSbyte R
4	LSbyte R	0

See the ANGLES command for the format and scaling of the angle values sent.

REPORT RATE **REPORT RATE**

Measurement Rate Divisor Command	ASCII	HEX	DECIMAL	BINARY
1	Q	51	81	01010001
2	R	52	82	01010010
8	S	53	83	01010011
32	T	54	84	01010100

If you do not want a BIRD data record output to your host computer every BIRD measurement cycle when in STREAM mode, use the REPORT RATE command to change the output rate to every other cycle (R), every eight cycles (S) or every thirty-two cycles (T). If no REPORT RATE command is issued, transmission proceeds at the measurement rate by default.

RS232/ISA TO FBB

RS232/ISA TO FBB

	HEX	DECIMAL	BINARY (Normal/Expanded/Super-Expanded Addressing mode)		
Command Byte	F0/E0/A0	240/224/160	11110000/11100000/10100000	+	FBB ADDR

If you have multiple pcBIRD cards in a common chassis, you can send commands and receive data by talking to each card individually using the ISA bus. If you have pcBIRD cards in multiple chassis interconnected with an FBB bus and want to control them from a single chassis, you need to use the RS232/ISA TO FBB command. The command can ONLY be used when communicating with the master BIRD. When in Normal or Expanded Addressing modes, the RS232/ISA TO FBB command is 1 Byte long. When is Super-Expanded Addressing mode, the command is 2 Bytes long.

For the Normal Addressing mode (addresses 1 to 15), the command looks like:
Command Byte = F0 + destination FBB address in Hex
(i.e. FBB address 1 (1 Hex) would be F1
FBB address 14 (E Hex) would be FE)

For the Expanded Addressing mode (addresses 1 to 30), the command looks like:
Addresses 1 to 15:
Command Byte = F0 + destination FBB address in Hex
(i.e. FBB address 1 (1 Hex) would be F1
FBB address 15 (F Hex) would be FF)
Addresses 16 to 30:
Command Byte = E0 + destination FBB address in Hex - 10 Hex
(i.e. FBB address 16 (10 Hex) would be E0)
FBB address 30 (1E Hex) would be EE)

For the Super-Expanded Addressing mode (addresses 1 to 126), the command looks like:
Command Byte 1 = A0
Command Byte 2 = destination FBB address in Hex

Example 1: There are two BIRDs in the Flock in the Normal Addressing mode -- one at FBB address 1 and the other at FBB address 2, configured for the 1 transmitter/2 sensor mode. By default, the pcBIRD at address 1 is the Master and the pcBIRD at address 2 is the Slave.

To get Position/Angle data from BIRD 1, the host would either send:

- a 2 byte command consisting of the RS232/ISA TO FBB command, F1 (Hex), followed by the POINT command, 42 (Hex).
- or the 1 byte POINT command 42 (Hex).

To get Position/Angle data from BIRD 2, the host would send:

- a 2 byte command consisting of the RS232/ISA TO FBB command, F2 (Hex), followed by the POINT command, 42 (Hex).

Example 2: There are two BIRDs in the Flock in the Super-Expanded Addressing mode -- one at FBB address 1 and the other at FBB address 2, configured for the 1 transmitter/2 sensor mode. By default, the pcBIRD at address 1 is the Master and the pcBIRD at address 2 is the Slave.

To get Position/Angle data from BIRD 1, the host would either send:

- a 3 byte command consisting of the RS232/ISA TO FBB command, A0 (Hex), the destination FBB address in Hex (01), and the POINT command, 42 (Hex).
- or the 1 byte POINT command 42 (Hex).

To get Position/Angle data from BIRD 2, the host would send:

- a 3 byte command consisting of the RS232/ISA TO FBB command, A0 (Hex), the destination FBB address in Hex (02), and the POINT command, 42 (Hex).

Notes:

1) To use STREAM mode with multiple BIRDs, first send the GROUP MODE command to the Master before sending the STREAM command to the Master.

2) Data output from the Master may be delayed up to 2 milliseconds (when running at 100 measurements/second) from the time the RS232/ISA TO FBB command is issued.

RUN **RUN**

	ASCII	HEX	DECIMAL	BINARY
Command Byte	F	46	70	01000110

The RUN command is issued to the Master BIRD, but not to the Slave BIRD, to start the BIRDs FLYing or to the standalone BIRD to restart normal system operation after it has been put to sleep with the SLEEP command. RUN does not reinitialize the system RAM memory, so any configuration or alignment data entered before the system went to SLEEP will be retained.

SLEEP **SLEEP**

	ASCII	HEX	DECIMAL	BINARY
Command Byte	G	47	71	01000111

The SLEEP command turns the transmitter off and halts the system. The command is issued to the Master BIRD or the standalone BIRD but not to the Slave BIRD. While asleep, the BIRD will respond to data requests and mode changes, but the data output will not change. To resume normal system operation, issue the RUN command.

STREAM **STREAM**

	ASCII	HEX	DECIMAL	BINARY
Command Byte	@	40	64	01000000

In the STREAM mode, the pcBIRD starts sending continuous data records to the host computer as soon as the @ Command Byte is received. Data records will continue to be sent until the host sends the POINT or OUTPUT BUFFER CLEAR commands. If you use the POINT command to stop the streaming, you will receive an additional data record in response to the POINT command. It is the user's responsibility to clear the BIRD's output port of any unread words after issuing the POINT command.

See REPORT RATE to change the rate at which records are transmitted during STREAM.

SYNC **SYNC**

	ASCII	HEX	DECIMAL	BINARY
Command Byte	A	41	65	01000001

Command Data	SYNCtype

The SYNC command must be issued to the pcBIRD in the following 2-byte sequence:

```
MSB                                   LSB
 7    6    5    4    3    2    1    0      BYTE #

 0    1    0    0    0    0    0    1      #1 Command Byte
 D7   D6   D5   D4   D3   D2   D1   D0     #2 Command Data
```

Where D7-D0 = 00000000 for no sync
= 00000001 for CRTSYNC type 1
= 00000010 for CRTSYNC type 2
= 00001000 for HOSTSYNC type 1
= 11111111 for CRTSYNC type 255, pickup placement

The pcBIRD offers several methods of synchronizing its operation and outputs to external events. All user supplied synchronization signals and requests must be directed to the current Master BIRD or to a standalone unit.

CRTSYNC Modes

If you are using the sensor or three-button mouse within a few feet of a magnetically deflected cathode ray tube, the pcBIRD's outputs may become noisy. Use the SYNC command in conjunction with the CRT sync cable shipped with your unit to eliminate this noise. The CRT sync pickup must be plugged into the pcBIRD's SYNC connector located on its back panel before you execute any of the SYNC (CRT Mode) commands.

The single Command Data byte, SYNCtype, that you send with the SYNC command controls the operation of the pcBIRD with respect to your CRT's vertical scan. Set SYNCtype = 0 (system power-up default) if you do not want the pcBIRD to be synchronized to either the operation of your CRT or the host computer. Set SYNCtype = 1 to synchronize the pcBIRD to your CRT if your CRT has an unusually high vertical retrace rate, that is, greater than 72 cps but less than 144 cps. When SYNCtype is 1, the pcBIRD makes measurements at the sync rate. For best performance SYNCtype should only be set to 1 if the sync rate is at least 100 cycles per second. Set SYNCtype = 2 to synchronize the pcBIRD to your CRT if your CRT's vertical retrace rate is in the normal range of 50 to 72 cps. When SYNCtype is 2, the pcBIRD makes measurements at twice this rate, that is, from 100 to 144 updates per second. Before you set SYNCtype = 1 or 2, you should use SYNCtype = 255 to determine your CRT's vertical retrace rate and to help you find the best spot on the outside of the CRT's housing for the sync pickup. Each time you send SYNCtype = 255, the pcBIRD will return two words to aid you in finding the "sweet spot". The first word represents a voltage proportional to the strength of your CRT's vertical scan signal. Locate the pickup where this voltage will be at least 1 volt or more. The maximum voltage reading will be obtained on the top or side of your CRT's housing near the deflection yoke. The deflection yoke is typically located about halfway between the front and back of the cabinet. The second word represents the scan rate of your CRT. If you get a voltage reading but the scan rate number remains zero, it means that your CRT's vertical scan rate is less than 31 cps. The pcBIRD will not synchronize to a CRT at these lower rates. When you set SYNCtype = 255, the front panel light will go out to remind you that the pcBIRD is not running normally. You must set SYNCtype NOT equal to 255 before the pcBIRD will start running again.

The two words returned each time you issue the command with the Command Data = 255 are formatted per the following, with no “phasing” bits employed:

WORD #	Most Significant Byte	Least Significant Byte
1	MSByte scan voltage	LSByte scan voltage
2	MSByte scan rate	LSByte scan rate

The scan voltage will return values between 7FFF and 8000 Hex. Element scaling is 7FFF Hex = 4.99 volts, 0 = 0 Hex = 0 volts and 8000 Hex = -5.0 volts.

The scan rate measurement will return timer COUNTS between 0 and FFFF Hex. After converting COUNTS to an integer between 0 and 65535, the scan rate is computed from:

scan rate in hertz = 500,000 / (CLOCK * COUNTS)

where CLOCK is the period of one computer time count in microseconds. With a crystal value equal to 32 MHz, CLOCK = 8 / 32. With a 40 MHz crystal, CLOCK = 8 / 40. The crystal value is determined by using the command EXAMINE VALUE/BIRD COMPUTER CRYSTAL SPEED.

HOSTSYNC Mode

When SYNCtype = 8, the pcBIRD is in host sync mode. In this mode, the pcBIRD starts a measurement cycle only when the RS232 commands POINT or STREAM are received from your host computer. In addition to starting a measurement cycle, the pcBIRD starts outputting the most recent position and orientation data record. The data output is approximately 5 milliseconds old when it starts coming out. When the STREAM command is received, the next measurement cycle starts immediately, but the output of the data record is delayed for approximately 5 milliseconds while it is being computed. Issue the STREAM command every cycle to obtain data records that are zero milliseconds old. An important note to this command is that the user must issue the POINT or STREAM commands at a regular rate with a frequency of 100 Hz to 144 Hz. If you just issue the POINT or STREAM commands every now and then when SYNCtype = 8 is in force, the resulting position and orientation data returned will be greatly in error. When operating with an ERC using a single RS232 interface to talk to all Flock members, only the Master outputs its data on receipt of the POINT command. The host must individually request data from the Slaves.

If your host is going to send data requests at a rate greater than the pcBIRD's default measurement rate of approximately 103.3 measurements/sec, you must first use the CHANGE VALUE BIRD MEASUREMENT RATE command to set the pcBIRD to a rate that is slightly faster than the host's fastest rate (i.e. if the host's rate is 120 measurements/sec set the pcBIRD to 123 measurements/sec).

Since the pcBIRD is ready to output position and orientation data about 6 milliseconds before it is able to start a new measurement cycle, you should use the CHANGE VALUE DISABLE/ENABLE DATA READY mode instead of the HOSTSYNC mode if you want to minimize data lag.

XOFF **XOFF**

	ASCII	HEX	DECIMAL	BINARY
Command Byte	DC3	13	19	00010011

The ERC responds to the XON/XOFF commands which many computers use for RS-232C flow control. When your host computer sends the ERC an XOFF, the unit will halt transmission at the end of the current output record. It will not halt transmission the instant it receives the command. If you need to halt the flow instantly, use the RS-232C DATA TERMINAL READY SIGNAL that your host computer's UART sends over the RS-232C cable to the ERC. The XOFF command cannot be sent to the ERC mixed in with the Command Data of another command, as it simply will be interpreted by the ERC as Command Data.

Note: This is an RS232 command only.

XON **XON**

	ASCII	HEX	DECIMAL	BINARY
Command Byte	DC1	11	17	00010001

The ERC responds to the XON/XOFF commands which many computers use for RS-232C flow control. When your host system sends the ERC an XON, the unit will resume transmission of any data records that were pending when it was XOFFed (see XOFF). The XON command cannot be sent to the ERC mixed in with the Command Data of another command, as it simply will be interpreted by the ERC as Command Data.

Note: This is an RS232 command only.

11.0 ERROR MESSAGES

The pcBIRD keeps track of system errors. When an error occurs, the SYSTEM STATUS register ERROR bit is set to a '1', and the error code is put into the ERROR CODE register. The user can query the SYSTEM STATUS register by using the EXAMINE VALUE SYSTEM STATUS command. The ERROR CODE register can be read by using the EXAMINE VALUE ERROR CODE command. When the user reads SYSTEM STATUS, the ERROR bit is reset to a '0', and when the user reads the ERROR CODE register, all bits are reset to '0'.

When an error occurs, the LED light on the top of the card will temporarily or permanently stop the pcBIRD and blink the error code as 10 short blinks followed by N long blinks, where N is the error code. The stopping of the pcBIRD and blinking during an error condition can be disabled using the CHANGE VALUE/ERROR DETECT MASK command. Most error conditions can be cleared up by resetting the card or reissuing the AUTO-CONFIGURATION command to the master in a Master/Slave configuration.

The error codes are summarized on the next page. A detailed description of each is presented later.

CODE	ERROR DESCRIPTION	TYPE
1	System Ram Failure	FATAL
2	Non-Volatile Storage Write Failure	FATAL
3	PCB Configuration Data Corrupt	WARNING1
4	BIRD Transmitter Calibration Data Corrupt or Not Connected	WARNING1
5	BIRD Sensor Calibration Data Corrupt or Not Connected	WARNING1
6	Invalid Command	WARNING2
7	Not an FBB Master	WARNING2
8	No BIRDs Accessible in Device List	WARNING2
9	BIRD is Not Initialized	WARNING2
10	FBB Serial Port Receive Error - Intra BIRD Bus	WARNING1
11	RS232 Serial Port Receive Error	WARNING1
12	FBB Serial Port Receive Error - FBB Host Bus	WARNING1
13	No FBB Command Response	WARNING1
14	Invalid FBB Host Command	WARNING1
15	FBB Run Time Error	FATAL
16	Invalid CPU Speed	FATAL
17	No FBB Data	WARNING1
18	Illegal Baud Rate	WARNING1
19	Slave Acknowledge Error	WARNING1
20-27	Intel 80186 CPU Errors	FATAL
28	CRT Synchronization	WARNING1
29	Transmitter Not Accessible	WARNING1
30	Extended Range Transmitter Not Attached	WARNING1
31	CPU Time Overflow	WARNING2
32	Sensor Saturated	WARNING1
33	Slave Configuration	WARNING1
34	Watch Dog Timer	WARNING1
35	Over Temperature	WARNING1

MESSAGE TYPE	DESCRIPTION
FATAL	Error is posted in system status, panel light continuously blinks the error code, the Flock stops running.
WARNING1	Error is posted in system status, panel light blinks the error code once, the Flock resumes operation after the blinking stops.
WARNING2	Error is posted in the system status, no light blinking, the Flock continues to run.

11.1 ERROR MESSAGE DETAILS

For each of the Flock error codes, a possible cause and corrective action are listed. Corrective actions with an * indicate the user should not attempt this fix. Ascension Technology should be contacted by phone 802-893-6657, fax 802-893-6659 or email techsupport@ascension-tech.com.

CODE	ERROR DESCRIPTION	TYPE
1	RAM Failure Cause: System RAM Test did not PASS. Action: *Check for shorts or opens to the RAM chips and if OK, replace system RAM.	FATAL
2	Non-Volatile Storage Write Failure Cause: Occurs when trying to write a transmitter, sensor, or PCB EEPROM but the device does not acknowledge either because it is not there or there is a circuit failure. Action: *Check the target EEPROM via a read command to verify that it is present prior to writing the device.	FATAL
3	PCB Configuration Data Corrupt Cause: The system was not able to read the PCB EEPROM 'Initialized Code'. Action: *Verify that the error persists after removing the transmitter and the sensor.	WARNING1
4	Transmitter Configuration Data Corrupt Cause: The system was not able to read the Transmitter EEPROM 'Initialized Code' or the Transmitter is not plugged in. Action: *Insure that the Transmitter is present, calibrate the transmitter, and set the 'Initialized Code' in the EEPROM.	WARNING1
5	Sensor Configuration Data Corrupt Cause: The system was not able to read the Sensor EEPROM 'Initialized Code' or the Sensor is not plugged in. Action: *Insure that the Sensor is present, calibrate the sensor, and set the 'Initialized Code' in the EEPROM.	WARNING1
6	Invalid Command Cause: The system has received an invalid command, which can occur if the user sends down a command character that is not defined or if the data for a command does not make sense (i.e., change value commands with an unknown parameter number). Action: Only send valid commands to the BIRD.	WARNING2

* Do not attempt to fix this error. Contact Ascension Technology at 802-893-6657.

CODE	ERROR DESCRIPTION	TYPE
7	Not an FBB Master Cause: The system received a command which should only be sent to the Master BIRD. Action: Send the command with the address of the Master. As a note, commands which should only be sent to the Master BIRD can be sent to the BROADCAST address.	WARNING2
8	No BIRDs Accessible in Device List Cause: The Master BIRD detects that no BIRDs are accessible in the FBB Devices word part of the FBB Configuration Command. Action: All accessible BIRDs must be indicated in the FBB Devices part of the FBB Configuration Command.	WARNING2
9	BIRD is Not Initialized Cause: The Master BIRD is sent the Run command, but it has not been initialized via the FBB Configuration command. Action: Send the FBB Configuration command prior to sending the Run or the WAKE UP command.	WARNING2
10	FBB Receive Error - Intra BIRD Bus Cause: Either an overrun or framing error has been detected by the serial channel 0 UART as it received characters from another BIRD on the internal RS485 interface. Action: If all BIRDs have the proper crystal installed, this error should never occur.	WARNING1
11	RS232 Receive Overrun or Framing Error Cause: An overrun or framing error has been detected by the serial channel 1 UART as it received characters from the user's host computer on the RS232 interface. Action: If an overrun error, the baud rate of the user's host computer and the BIRD differ. This may be due to incorrect baud selection, inaccuracy of the baud rate generator, or the RS232 cable is too long for the selected baud rate. If a framing error, the host software may be sending characters to its own UART before the UART finishes outputting the previous character.	WARNING1
12	FBB Receive Error - FBB Host Bus Cause: Either an overrun or framing error has been detected by the serial channel 1 UART as it received characters from the user's host computer on the RS485 interface. Action: If an overrun error, the baud rate of the user's host computer and the BIRD differ. This may be due to incorrect baud selection or inaccuracy of the baud rate generator. If a framing error, the host software may be sending characters to its own UART before the UART finishes outputting the previous character.	WARNING1

* Do not attempt to fix this error. Contact Ascension Technology at 802-893-6657.

CODE	ERROR DESCRIPTION	TYPE
13	No FBB Command Response Cause: The Master BIRD has sent a command to a Slave BIRD that required a response, but the Slave never responded. Action: Check that the Slave BIRDs are attached. Check FBB cabling. Check that Slave BIRD addresses match the FBB Configuration.	WARNING1
14	Invalid FBB Host Command Cause: The Flock has received an invalid FBB host command which can occur if the user sends down a command character to the proper device address but the command is invalid. Action: Only send valid FBB commands to the BIRD when in FBB Host control mode.	WARNING1
15	FBB Run Time Error Cause: Not currently used. Action: Should never occur.	FATAL
16	Invalid CPU Speed Cause: If the system reads an invalid CPU speed from the system EEPROM and the EEPROM is initialized, the error will occur. Action: *Initialize the system EEPROM.	FATAL
17	No Data Error Cause: When a Slave is expecting data from the Master and does not receive data, this error will occur. Action: This error should not occur.	WARNING1
18	Illegal Baud Rate Error Cause: If the dip switch is in an 'invalid' baud rate setting then this error will occur. Action: Set dip switch to a valid baud rate setting.	WARNING1
19	Slave Acknowledge Error Cause: This error will occur if the Master sends a multibyte command to a Slave and the Slave does not respond. For example, if the user sends the Master the Auto-Configuration Command with 2 Flock units, and the BIRD at address #2 is not connected to the FBB or not in FLY mode, during the Auto Configuration process, the Master will display this error. Action: Assure that all unit configurations are correct, all units are attached to the FBB and at the proper address, and all units are in FLY mode.	WARNING1
20	Unused_INT4 Cause: CPU Overflow. Action: *Check code for INTO instruction.	FATAL
21	Unused_INT5 Cause: Array Bounds. Action: *Check code for BOUND Instruction.	FATAL

* Do not attempt to fix this error. Contact Ascension Technology at 802-893-6657.

CODE	ERROR DESCRIPTION	TYPE
22	Unused_INT6 Cause: Unused Opcode. Action: *CPU has executed an invalid opcode. Possibly bad (or going bad) EPROM. Also, check the power supply to assure that the +5VD is not dropping below 4.75 volts even when the transmitter is running.	FATAL
23	Unused_INT7 Cause: ESC Opcode. Action: *Check code for the ESC Instruction.	FATAL
24	Unused_INT9 Cause: Reserved. Action: *Should never occur.	FATAL
25	Unused_INT10 Cause: Reserved. Action: *Should never occur.	FATAL
26	Unused_INT11 Cause: Reserved. Action: *Should never occur.	FATAL
27	Unused_INT16 Cause: Numeric coprocessor exception. Action: *Numeric CPU does not exists, so this should never occur. Check to make sure the ERROR/signal on the CPU is tied to +5VD.	FATAL
28	CRT Synchronization Error Cause: When in CRT Synchronization mode, if the CRT synchronization signal is not present, this error will occur. Action: Assure that the synchronization signal is present using the Display CRT Synchronization Information command.	WARNING1
29	Transmitter Not Accessible Error Cause: This error occurs when the host starts the system FLYing via the Auto-Configuration command and a BIRD which should have a transmitter does not have a transmitter. Action: Assure that the specified BIRD has a transmitter.	WARNING1
30	Extended Range Transmitter Not Attached Error Cause: If the Extended Range Controller does not have an Extended Range Transmitter attached, this error will occur. Action: Assure that the Extended Range Controller has a Extended Range Transmitter attached.	WARNING1

* Do not attempt to fix this error. Contact Ascension Technology at 802-893-6657.

CODE	ERROR DESCRIPTION	TYPE
31	CPU Time Overflow Error Cause: This error occurs if the CPU in the BIRD or Extended Range Controller runs out of CPU time. This can occur if the host overburdens the BIRD with multiple commands in a measurement cycle. Action: The host can either slow down the measurement rate or decrease the number of commands sent to the BIRD.	WARNING2
32	Sensor Saturated Error Cause: This error occurs if the sensor is saturated during power-up. This will occur if the sensor is not connected, the sensor or cable is damaged, a large magnetic field is present, or the sensor is sitting on a steel table. Action: The User should check that the sensor is attached to the BIRD (screw in the connector) and that none of the other above-mentioned conditions exist.	WARNING1
33	Slave Configuration Error Cause: This error occurs if the Master determines that a Slave is not configured with a sensor during the Auto-Configuration command. Action: Verify that all the Slaves have their sensors attached.	WARNING1
34	Watch Dog Error Cause: This error occurs on an Extended Range Controller if the CPU does not update the Watch Dog Timer within a 100 mS period. This will only occur if the CPU or ROMs fail during operation. Action: *Should never occur.	WARNING1
35	Over Temperature Error Cause: This error occurs on an Extended Range Controller if the transmitter driver overheats. This can occur if the fan in the controller fails or if the ambient temperature of the controller exceeds operating specifications. Action: Verify that the fan is operating.	WARNING1

* Do not attempt to fix this error. Contact Ascension Technology at 802-893-6657.

12.0 TROUBLE SHOOTING

If you are experiencing trouble with the pcBIRD, try the following:

IF YOU CANNOT TALK TO THE pcBIRD WITH THE ISA INTERFACE:

1) With the power off to the host computer, verify that the pcBIRD card is seated into the host computer's ISA bus connectors.

2) Check that the Base Address dip switch is set to the correct value.

3) Verify that no other cards in your chassis use Base Address+0, +1, +2 or +3.

4) Check that the IRQ jumpers are set correctly. There should be no jumpers if you are using pcBIRD in a polled mode.

IF YOU CAN COMMUNICATE WITH THE pcBIRD BUT THE DATA IS BAD:

1) Make sure all cables are plugged in, and plugged into the correct connectors.

2) If you send commands without their proper command data bytes or the wrong number of data bytes, the system may hang. Reset the system to return you to normal operation.

There are no fuse or other user-serviceable parts on the pcBIRD's circuit board.

For technical assistance call Ascension Technology at 802-893-6657 between the hours of 9 AM and 5 PM Eastern Standard Time or fax us at 802-893-6659.

APPENDIX I - NOMENCLATURE

FBB	Fast BIRD Bus. A high baud rate RS485 interface interconnecting the pcBIRD units. The FBB is used by the BIRDs for talking among themselves.
FLOCK	A Flock is one or more sensors and/or transmitters that are connected together to make a single system.
MASTER	The Master BIRD is the Flock BIRD that is controlling and coordinating the operation of all other Flock BIRDs (the Slaves). The Master controls the sequencing and synchronizing of Flock transmitters and tells sensors when to measure the transmitted magnetic fields. The user's host computer communicates with the Master to start and stop the Flock and perform other major Flock control functions. There can only be one Master running on the FBB at a time. The Master BIRD may have its own transmitter but this is not a requirement. The Flock can run using a transmitter attached to a Slave. All BIRDs in the Flock must have a sensor unless it is an ERC (Extended Range Controller).
SLAVE	One or more BIRDs in the Flock with a sensor and possibly a transmitter that receive operating instructions from the Master BIRD. If the Slave unit has a transmitter, the user's host computer may tell the Master to turn on this Slave's transmitter via the NEXT TRANSMITTER command.
NOISE	Noise is when you place a sensor in a stable location and the sensor still looks like it is moving. Noise can come from many places in your environment including, but not limited to: power lines, monitors, transformers, overhead lights, fuse boxes, etc.
CRT	The CRT (Cathode Ray Tube) is the monitor that connects to the host computer.
ISA BUS	The ISA bus is the interface that the computer uses to talk to the pcBIRD.

I/O ADDRESS	Is the dip switch assigned address that the user selects for communication with the pcBIRD. Each electronic unit must have a unique I/O address.
EULER ANGLE	These are the rotations about the axes. The Azimuth is the rotation about the Z axis, the Elevation is the rotation about the Y axis, and the Roll is the rotation about the X axis.
FLYING	This is the state that the BIRD is in immediately after power on. This is the running state.

APPENDIX II - pcBIRD SPECIFICATIONS

Physical

Transmitter:	3.75" cube with 10' cable or optional Extended Range Transmitter 12" cube with 20' cable.
Sensor:	1.0" x 1.0" x 0.8" cube (or optional 3-button mouse) with 10' or 35' cable.
PC Board:	Standard full-length board (one per sensor to be tracked)
ERC Enclosure (optional):	4½" x 11¾" x 9 **f** " (± **c**)

Technical

Positional range:	± 4' (± 10' optional) in any direction
Angular range:	± 180^{o} Azimuth & Roll ± 90^{o} Elevation
Static positional accuracy:	0.07" RMS @ 12" with Standard Range Transmitter
Positional resolution:	0.02" RMS @ 12" with Standard Range Transmitter
Static angular accuracy:	0.5^{o} RMS @ 12" with Standard Range Transmitter
Angular resolution:	0.1^{o} RMS @ 12" with Standard Range Transmitter
Update rate:	30-144 measurements/sec
Outputs:	X, Y, Z positional coordinates and orientation angles: rotation, matrix, or quaternions
Interface:	ISA-Bus RS232: 2,400 to 115,200 Baud (ERC Only)
Format:	Binary
Modes:	Point or Stream

Electrical

pcBIRD Power requirements:	Uses PC's power supply (5V @ 4.5A, 12V @ 1.5A No -5V or -12V)	
ERC Power requirements:	100-120/200-240	Voltage
	47-63Hz	Frequency Range
	3.6A/1.8A	Amperage

Environment All specifications are valid at 30^{o} C ± 10^{o} in an environment void of large metal objects and electromagnetic frequencies, other than the power line.

APPENDIX III - JUMPER FUNCTIONS

Jumper assignments on each pcBIRD card

Jumper	Function
1	1 - 2 connected, CRT sync signal enable * 2 - 3 connected, TTL sync signal enable
2	1 - 2 connected, CRT sync signal enable * 2 - 3 connected, TTL sync signal enable
3	1 - 2 connected, FBB Reset is enabled 1 - 2 not connected, FBB Reset is not enabled *
4	1 - 2 connected, RS485 HOST BUS data is terminated 1 - 2 not connected, RS485 HOST BUS data is not terminated *
5	1 - 2 connected, BIRD BUS CTS is terminated 1 - 2 not connected, BIRD BUS CTS is not terminated *
6	1 - 2 connected, BIRD BUS data is terminated 1 - 2 not connected, BIRD BUS data is not terminated *
7	1 - 2 connected, RAM size = 32K x 8 enable * 2 - 3 connected, RAM size = 8K x 8 enable
8 - 12	Do not exist
13	1 - 2 connected, using ISA bus interface * 2 - 3 connected, not using ISA bus interface
14	1 - 2 connected, using ISA bus for power on reset * 2 - 3 connected, not using ISA bus for power on reset

Notes: * indicates factory default setting

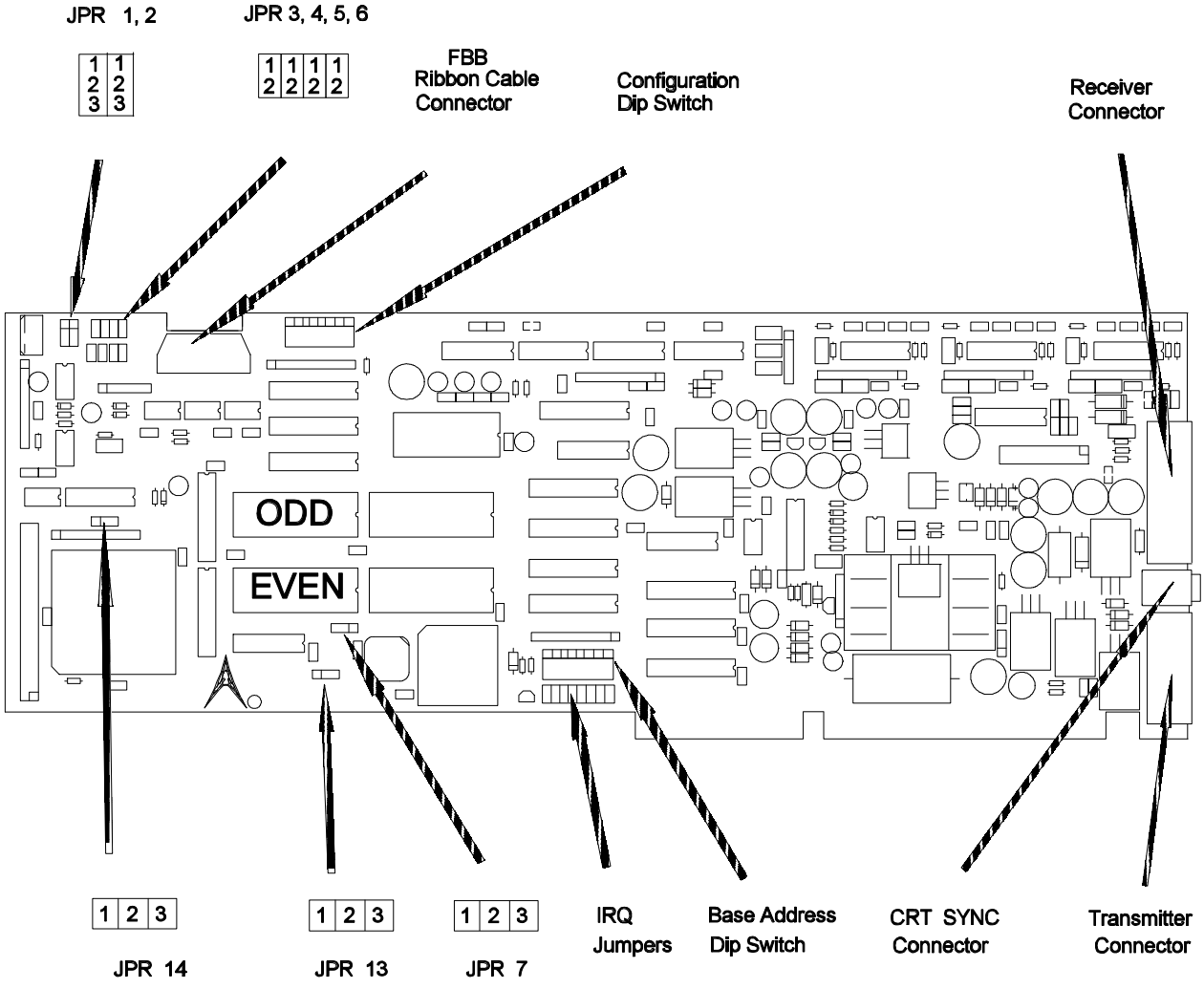
Jumper assignments on the ERC circuit card

Jumper	Function
1,2	do not exist
3	1 - 2 connected when using RS485 host control 1 - 2 not connected when using RS232 host control *
4-9	do not exist
10	1 - 2 connected, BIRD BUS CTS terminated * 1 - 2 not connected, BIRD BUS CTS not terminated
11	1 - 2 connected, FBB reset is enabled 1 - 2 not connected, FBB reset is not enabled *
12	1 - 2 connected, RS485 host receive data enabled 2 - 3 connected, RS232 host receive data enabled *
13	does not exist
14	1 - 2 connected, BIRD BUS data terminated * 1 - 2 not connected, BIRD BUS data not terminated
15	does not exist
16	1 - 2 connected, RS485 HOST BUS data terminated * 1 - 2 not connected, RS485 HOST BUS data not terminated

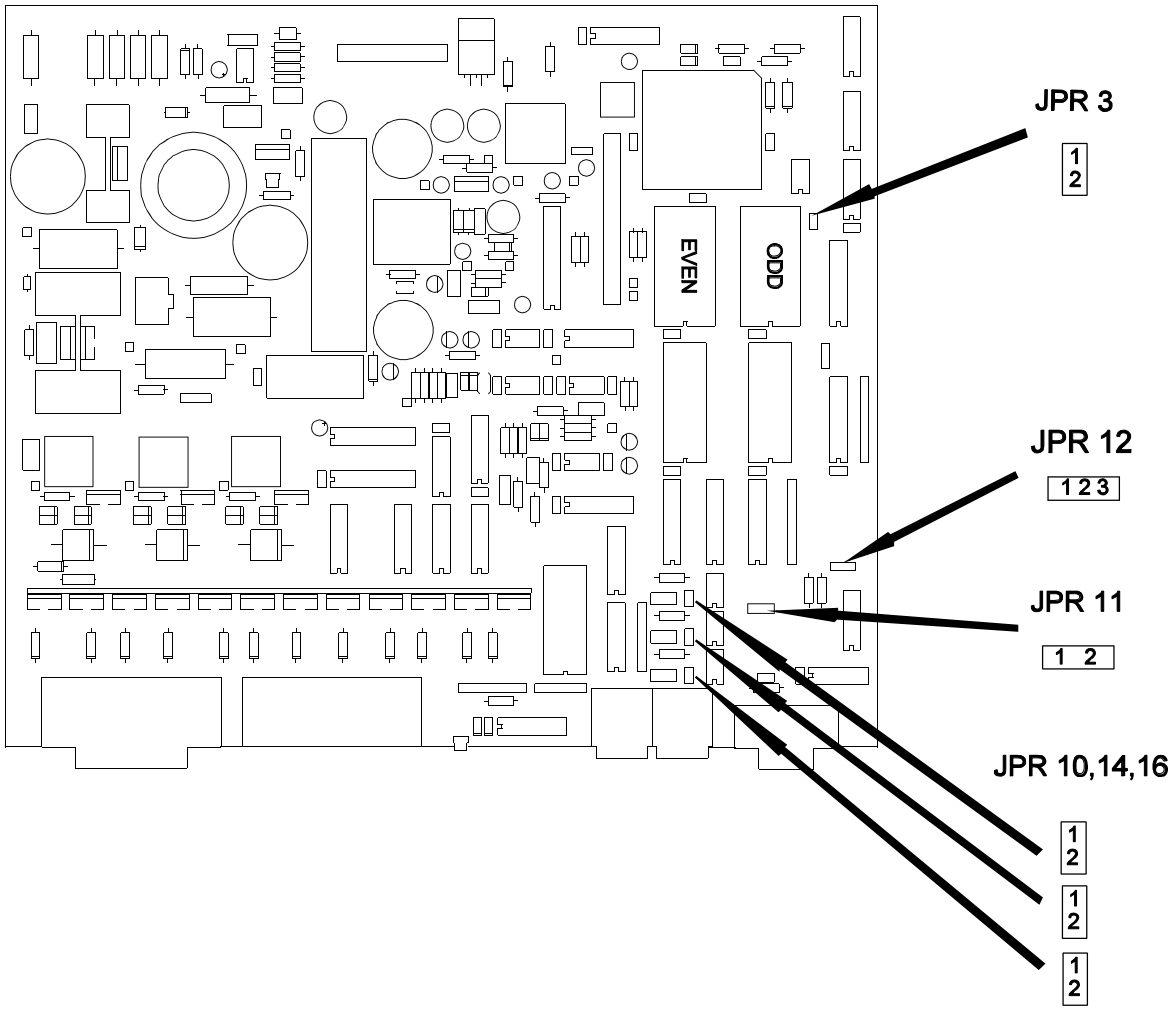
Notes: * indicates factory default setting

APPENDIX IV - JUMPER LOCATIONS ON THE CIRCUIT BOARDS

The pcBIRD Circuit Card Jumper Locations



The Extended Range Controller Circuit Card Jumper Location



APPENDIX V - USING THE pcBIRD AS A SLAVE WITH A NON-pcBIRD MASTER

The pcBIRD is most often used while the pcBIRD is the FBB Master unit or in stand alone mode. In the configurations no software precaution is needed.

In the cases where a Flock of Birds or ERC electronic unit is the Master and a pcBIRD with transmitter is the Slave, care must be taken in the software setup. For this configuration, the Master is sent the following commands:

1. CHANGE VALUE TRANSMITTER OPERATION MODE *Cool-Down or Pulsed mode*.

2. (If pcBIRD transmitter is being used) NEXT TRANSMITTER *the FBB address of the Slave pcBIRD*.

3. CHANGE VALUE FBB AUTO CONFIG *Number of units in Flock*.

The pcBIRD will not run in Non-Pulsed mode which is the default mode of the Flock of Birds electronic units, the MotionStar cards, and the ERC. If the CHANGE VALUE TRANSMITTER OPERATION MODE is not used in the command stream, the data will appear unstable and very jumpy. This is the result of the pcBIRD's measurement time not being synchronized with the non-pcBIRD Master.

If the transmitter is on the Master BIRD and the Master is an ERC or an Flock of Birds, then the CHANGE VALUE TRANSMITTER OPERATION MODE command should be sent to every BIRD in the Flock. This will guarantee that each BIRD is using the correct measurement timing.

APPENDIX VI - APPLICATION NOTES

Application Note #1

Computing the Coordinates of a Stylus Tip

Some applications need to measure the X, Y, Z coordinates that describe the physical shape of an object such as a plastic model or a person's face. This measurement can be accomplished by moving the pcBIRD's sensor over the object and recording the X, Y, Z positional outputs. Because of the sensor's size, it is sometimes more convenient to mount the pcBIRD's sensor onto a pencil or pen or some other device with a pointed tip (generically called a stylus) and then trace the object with the stylus tip to record its shape. Since the positional outputs of the pcBIRD are given in relation to the center of the sensor, one needs to find the corresponding X, Y, Z coordinates at the tip of the stylus. This translation of coordinates is easily accomplished with the application of some elementary trigonometry given the POSITION/MATRIX outputs and the X, Y, Z offset distances from the pcBIRD's sensor center to the tip of the attached stylus.

Notation: X_B, Y_B, Z_B are the X, Y, Z position outputs from the pcBIRD, that is, the location of the sensor's center with respect to the transmitter's center.

X_O, Y_O, Z_O are the offset distances from the sensor's center to the tip of the stylus.

X_S, Y_S, Z_S are the coordinates of the stylus's tip with respect to the transmitter's center.

M(i, j) are the elements of the rotation matrix returned to the user when the user requests POSITION/MATRIX outputs. Definition of the individual matrix elements can be found in the User's manual under the heading MATRIX.

Math: The stylus coordinates can be computed from the following:

$$X_S = X_B + X_O * M(1,1) + Y_O * M(2,1) + Z_O * M(3,1)$$

$$Y_S = Y_B + X_O * M(1,2) + Y_O * M(2,2) + Z_O * M(3,2)$$

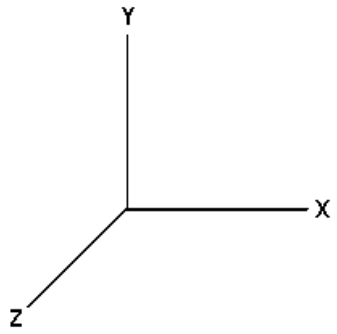
$$Z_S = Z_B + X_O * M(1,3) + Y_O * M(2,3) + Z_O * M(3,3)$$

Application Note #2

Converting the pcBIRD Outputs to a Graphics Modeling Matrix

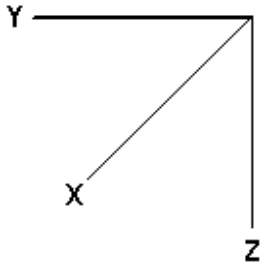
Purpose: Build the 12 elements of a standard computer graphics modeling matrix, MM(i, j), given the 9 matrix output elements from the pcBIRD, MB(i, j), and the pcBIRD's X, Y, Z position outputs Xpos, Ypos, and Zpos.

The standard computer graphics XYZ coordinate system is: positive X axis points to the right, positive Y axis points up, and positive Z points towards you.



Standard Graphic Mode

When the transmitter is between you and the graphics screen and the transmitter's power cord extends in the direction toward the screen the pcBIRD's XYZ coordinate system is: positive X axis points out of the screen, positive Y axis points to the left, positive Z axis points down.



Ascension's Graphic Mode

To have the screen image follow the rotations and translations of the pcBIRD's sensor so movement of the sensor toward the screen causes the image to move toward the front of the graphics screen, the following transformations from BIRD coordinates to modeling matrix elements are required:

```
MM(1,1) =   MB(2,2)
MM(1,2) =   MB(2,3)
MM(1,3) = - MB(2,1)
MM(1,4) =   0.
MM(2,1) =   MB(3,2)
MM(2,2) =   MB(3,3)
MM(2,3) = - MB(3,1)
MM(2,4) =   0.
MM(3,1) = - MB(1,2)
MM(3,2) = - MB(1,3)
MM(3,3) =   MB(1,1)
MM(3,4) =   0.
MM(4,1) = - Ypos
MM(4,2) = - Zpos
MM(4,3) =   Xpos
MM(4,4) =   1.0
```

Application Note #3

CRT Sync Pulse Electrical Requirements

If you need to synchronize the pcBIRD's measurement cycle to a piece of electronics equipment and it is not practical to use the sync pulse signal pickup provided with the pcBIRD, you can provide your own sync pulse to the pcBIRD. The sync pulse you provide must have the following characteristics:

1. The signal should be TTL level, normally low (ground).

2. The pcBIRD synchronizes to the rising edge of the pulse during its low to high transition.

3. Pulse width at the high level can vary from one microsecond to one millisecond.

4. Pulse width and pulse separation should be constant from one cycle to the next.

5. Pulse rep rate should be 50 to 72 Hz if using CRT SYNC type = 2 or 100 to 144 Hz if using CRT SYNC type = 1. Either of these combinations will result in a BIRD measurement rate of 100 to 144 measurements/second.

6. Change the jumpers on the pcBIRD's printed circuit card (PCB): (see Section 2.2.1.3). Jumper pins 2 to 3 on jumpers 1 and 2 if using a TTL input signal or jumper pins 1 to 2 on jumpers 1 and 2 if using the CRT SYNC pickup shipped with the pcBIRD.

Application Note #4

Configuring the pcBIRD for Minimum Lag

1. Use STREAM mode not POINT mode for collecting data. STREAM mode gives you data every BIRD measurement cycle as soon as it has been computed. If you used POINT mode, the data request would come at some random point in the pcBIRD's measurement cycle resulting in a random variation of up to 10 milliseconds in the 'age' of the unit's measured data.

2. Select an output format that transmits the minimum amount of data required. For example, if you only want to measure angles, then select ANGLE mode and not POSITION/ANGLE mode.

3. Unlock the outputs if you are going to be making sudden movements by setting the CHANGE VALUE, SUDDEN OUTPUT CHANGE LOCK command to zero.

4. Minimize the number of filters applied to the pcBIRD data. To determine which filters you can remove: 1) Set the pcBIRD's sensor at the maximum distance from the transmitter that you will be using in your application. 2) Use the CHANGE VALUE, FILTER ON/OFF STATUS command to remove one filter at a time. Observe the noise on the outputs of your measurements as you remove each filter. If the amount of noise is acceptable, leave the selected filter out. The DC filter will have the largest impact on noise and usually cannot be eliminated unless you are going to be running with the sensor close to the transmitter or you are going to filter your own data.

5. Minimize the amount of steady state filtering applied by the DC filter. Use the CHANGE VALUE, DC FILTER CONSTANT TABLE ALPHA_MIN command and increase ALPHA_MIN until the noise level is unsatisfactory. The closer the sensor is to the transmitter, the larger ALPHA_MIN can be.

6. Run the pcBIRD at a higher measurement rate. Use the CHANGE VALUE, BIRD MEASUREMENT RATE command and increase the unit's measurement rate from its default speed of approximately 103.3 measurements/second. You can increase the speed up to a maximum of approximately 144 measurements/seconds. As you increase the speed, you will note that the amount of noise in the pcBIRD measurements may be higher than or less than the amount of noise at the power-up default speed. The noise can increase or decrease rapidly with a speed change of just a few cycles/sec and then increase or decrease again as you continue to change the speed.

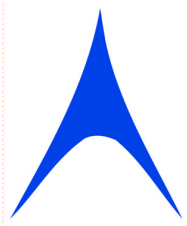
7. Reduce the amount of noise that the pcBIRD thinks is in the local environment by using the CHANGE VALUE, DC FILTER TABLE Vm command. Set the sensor at various distances from the transmitter and reduce the Vm value for this range until the noise is unacceptable. The biggest gain in dynamic performance, other than elimination of the DC filter, comes from reducing Vm.

8. Reduce the amount of filtering during the steady state part of fast movements by using the CHANGE VALUE, DC FILTER CONSTANT TABLE ALPHA_MAX. Set ALPHA_MAX as close to 0.999 as possible. The larger alpha_max is, the less lag there will be during fast motions. But note, the larger alpha_max is, the larger the noise will be during the movement.

At Ascension Technology, when we want a 'snappy' response with good noise characteristics, we use all system defaults except for the following overrides:

a). Stream mode
b). Sudden output change lock = 0
c). DC filter ON, AC narrow notch filter ON, AC wide notch OFF
d). Vm table = 2, 2, 2, 10, 10, 40, 200

where most of the 'snap' comes from the Vm table.



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