Application

- Multidimensional Multipoint Positioning
- Ultrasonic Guidance Systems
- Ultrasonic Tracking Systems
- Applicable in air and gasses

Features

- High Resolution 0.7mm
- High Repeatability
- Range over 10 meters
- Modular Construction

Introduction Ultrasonic Positioning

The Ultrasonic Positioning System (UPS) is a system of devices used for either tracking or guidance, or a combination of both. The components of the UPS are the Hexamite Positioning Devices featured below. These devices harness ultrasound for high resolution, high repeatability positioning. The smallest UPS conceivable consists of at least two Hexamite Positioning Devices where one device knows the distance to another. The Hexamite positioning devices are referred to as either Beacons (transmitters) or Pilots (receivers). Each Hexamite Pilot knows its distance to every Hexamite Beacon in range, with sub-millimeter resolution. Any Hexamite Positioning Device can be configured either as a Pilot or a Beacon; setup strings govern the operation of the devices. Your “Positioning System” may consist of an indefinite number of Hexamite Positioning Devices, configured as Pilots and Beacons, to form a large multi-point, multi-dimensional system that suits your needs.

Hexamite Positioning Device (HPD) HX900 is suited for tracking and guidance application. It has a built in 40KHz sensor and a high power output, which gives it an extra range. Low power options are available for battery operations. Indefinite number of HX900 devices can be connected together using multidrop RS485 networks, and spread over large areas for tracking or guidance operations. Direct RS232 via serial cable is also available for smaller systems.

Hexamite Positioning Device HX911P Series is designed for rugged industrial applications. It will operate with Hexamite standard sensors like the HE240 and HE240S series.

Hexamite Positioning Device HX944M has 4 transmission channels and 4 receive channels. This device can report the distance from any number of Beacons to 4 differently positioned sensors. This device is ideal for a single moving object guidance; it facilitates broader angle operation and can also provide object orientation data.

Important: *The positioning devices are sensitive. While connected to a computer, some ungrounded switching power supplies from laptops and desktops can disturb the positioning devices. In the event of interferenc, make sure all computers or terminals connected to the devices are well grounded. Laptops and terminals running on batteries do not disturb the devices while connected.*

Operation

The device can be configured through its serial port. It will accept a string of bytes, which affect the behavior of the device. These bytes are stored first in the work registers of the device and used for following operation. If the checksum matches the string, the configuration data is stored in the permanent nonvolatile memory. Once the string has been secured in permanent memory, the device will acknowledge by transmitting the ASCII character + via its serial port

The setup data is stored in EEPROM and will not be erased if the device is turned off. On startup, the setup string in the EEPROM is loaded into work registers and used by the program

Device Addresses

Each device has two addresses, a primary and a secondary address. The response of the device depends on the first byte in the string it receives. If the first byte is the primary address of the device, it responds by transmitting the data acquired during last acquisition.

The secondary address must always precede the setup string.

Configuration Data Interpretation

The first byte in the configuration string is the secondary address of the device. The second byte dictates the operation (Mode) of the device. The third byte determines how the device interacts with other devices in the group. The following is a list of the bytes and corresponding functions.

Configuration String

Byte	Parameter (hexadecimal)	Factory Settings
1	Program Control Byte (PCB)	00 hex
2	Termination Byte (TB)	0D hex
3	Number of Beacons Byte (NBB)	03 hex
4	Beacon Designation Byte (BDB)	02 hex
5	Noise Suppression Byte (NSB)	00 hex
6	Reserved	00 hex

The user can affect the operation of the device and control the configuration of the network by downloading the configuration data onto the network or radio link. This can be done via the serial port of any personal computer. An ordinary terminal program like "Microsoft Terminal" can be used for this operation. The setup data is stored in EEPROM and will not be erased if the Positioning Device is turned off. On startup, the setup string in the EEPROM is loaded into work registers and used by the program. If the ESC character is transmitted on the network, the program control byte PCB in the work register of all devices on the network is cleared. If the ESC character is used, the system must be either restarted or strings re-entered to resume normal operation.

Program Control Byte (PCB)

The Program Control Byte allows the mode of operation to be altered externally (over the RS485/RS232 or Radio link). For example, Bit 7 is the mode control bit; it sets the device as either a Beacon or a Pilot. If bit 7 is high the device is a Beacon, if this bit is low the device is a Pilot.

Bits	**Bit Function (Beacon)**
Bit 0	If set the system is synchronized using ultrasound.
Bit 1	Synchronization override.
Bit 2	Beacon is linked on a serial network.
Bit 3	Reserved (ignored)
Bit 4	Reserved (ignored)
Bit 5	Reserved (ignored)
Bit 6	Reserved (ignored)
Bit 7	If set, the device is a BEACON

Bit 1 Synchronization Override

The first Beacon to start the emission sequence sinks its synchronization I/O low. Beacons linked using the synchronization I/O are all synchronized to the first Beacon to start the emission sequence.

Bit.2: Serial Network

This bit should be set if the Beacons are serially linked to the Pilot network. If this bit is cleared, the Beacon will ignore all serial data on its serial input except the ESC character.

When the device is configured as a Pilot, it idles (waiting for serial input). If the primary address of the device is entered via the serial port input while it idles, the device responds by transmitting the results of its last position acquisition cycle. If hyphen "-" (synchronization) is entered via the serial port input, the device immediately enters position acquisition cycle. If bit 3 is set, the device will enter position acquisition cycle and submit the results through its serial port. If bit 1 of the Program Control Byte is set, the device will wait for a falling edge on its I/O synchronization pin before commencing with the position acquisition cycle.

Bits	Bit Function (Pilot)
Bit 0	The system is synchronized using ultrasound
Bit 1	Reserved
Bit 2	Reserved
Bit 3	If set the Pilot acquires position data continuously (used if it is the only Pilot on the network).
Bit 4	If set, the device is the master (initiator) on a network of devices or in the chain. When set, the device transmits the serial synchronization character hyphen (45) on the network.
Bit 5	Reserved
Bit 6	Reserved
Bit 7	If cleared, the device is a PILOT

Bit.0: If set, the Pilot is set up for sonic synchronization mode, and if transmission is enabled, the Pilot transmits the sonic synchronization signal.

Bit.3: If set, the Pilot continuously cycles through its program and transmits the results over the serial lines. This bit is useful when there is only a single Pilot or the Pilot is the only Pilot in operation on the network.

Bit.4: If set, the Pilot initiates the distance acquisition cycle once it receives a Carriage Return on the network. The Pilot with this bit set is the master on the network. It transmits the GO (ASCII equivalent to 45 decimal) signal (valid for both Pilots and Beacons) to the rest of the devices when it receives a Carriage Return. It also sinks the synchronization I/O to low momentarily just after GO has been transmitted.

General

Bit.0 is most often identical for both Pilots and Beacons, within an operating range. This bit sets these devices up for sonic synchronization. During sonic synchronization, the Pilot must be given an extra field. In other words, if you have Beacons designated as 1 and 2, and if the sonic bit is set, the Number of Beacon Byte (NBB) must be one larger than the number of Pilots, or NBB=BDB(max)+1 (see Device Control Bytes).

Noise Suppressor Byte (NSB).

The noise suppressor can be set from 00 to 18 (hex). The higher this number is, the harder it is to upset the measurement. At 00, no noise suppression is applied. At 18 hex, the 10m range is compromised. The noise suppression is achieved at the expense of the range. Low numbers may not have any significant effect on the range.

Termination Byte (TB)

This byte serves as the string termination byte and is also used to propel a network of chained devices. This byte can be used to force other devices to transmit their results.
If the termination byte of device 'X' is the primary address of device 'Y' on the same network, then final byte in the result string from device X forces device Y to transmit it's result string. See Master (Chain Initiator) section.

Number of Beacons Byte (NBB)

This number determines how many Beacons the Pilot looks for during the position acquisition cycle. It describes the system to the positioning device. All Pilots and Beacons in the system must contain the same value for the Number of Beacons Byte. The Pilot will submit via its serial port 1+NBB number of 16 bit position data segments. The size of the data segment depends on the number of channels the Pilot has. It is proper to refer to these segments as *Beacon Segments*. There is an extra segment that cannot be referred to as a Beacon segment; the *Synchronization Segment* would be more appropriate. The information in the synchronization segment relates to the Pilot itself. This segment can be used to establish current speed of sound for compensation and more (see application notes).

Beacon Designation Byte (BDB)

The Beacon Designation Byte applies only to Beacons, the Pilot ignores this number. The value of this byte determines the designation of the Beacon. The BDB must have a value less than or equal to the NBB. For example, the case of a 4 (BDB=3) point system, where three devices are configured as Beacons and one device configured as a Pilot. If the Number of Beacons Byte for all devices has the value three AND each Beacon has been given a different BDB value, for example 1, 2 and 3, then the Pilot will submit a data string similar to the following through its serial port.

0000 1A22 3334 14FF

This means that there are (1A22)=6690 millimeters from the Pilot to the device with BDB equal to 1, and (3334)=13108 millimeters to the device designated 2, and (14FF)=5375 millimeters to the Beacon designated 3. Note that the Synchronization Segment is 0000, it is always the first segment serially transmitted.

Using the same four point system, we can set it up as two Pilots and two Beacons. We can set the BDB of the system equal to two, so both Pilots look for two Beacons. We can set one Pilot up as master (active device) and the other as slave, then by typing the ASCII character 13 (Carriage Return) onto the network of the two Pilots, the system will submit the following string.

0833 2566 1FFF z2131 211B 1200

The above assumes the slave Pilot has a primary address equal to the ASCII character z. It is stated here that there are (2566)=9574 millimeters from the master Pilot to Beacon 1, and (1FFF)=8191 mm from the master Pilot to Beacon 2. There are (211B)=8475 mm from slave Pilot z to Beacon 1 and (1200)=4608 mm from slave Pilot z to Beacon 2. Since the Master Pilot was set up to transmit the sonic synchronization, there are (833)=2099 mm from the master to the nearest obstacle, and (2131)=8497 mm from Pilot slave z to the master.

Conversion example (converting a hexadecimal number to decimal).

211B = (2 x 16 x 16 x 16) + (1 x 16 x 16) + (1 x 16) + 11 = 8475 note that B = 11

Communication Protocol

Each device has a primary address and a secondary address. The secondary address is always the primary address + 1. The primary address is always an even number, and the secondary address is always an odd number. All broadcasted bytes are hexadecimal characters (0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F). Addresses and commands received by the device are binary (0-255). Addresses are in the range from 71 to 255, and 3 command (control characters) are used. Characters are ignored unless these directly apply, like ' Carriage Return ' (13), the character ' - ' (45), the character 'esc' (27) and own addresses. The character ' - ' (45) is interpreted by the devices on the network as a synchronization signal. This signal will plunge the devices into action as dictated by the set up.

Control Characters	Dec.	Hex.	Action
Carriage Return	13	0D	This will force the master device to transmit a hyphen, and activate all devices on the network.
Escape	27	1B	BREAK! Forces all devices to listen for commands.
Hyphen ' - '	45	2D	Network Synchronization, activates all initiated devices

If the ESC character is transmitted on the network, the Device Mode Control byte in the work register is cleared.

Idle (normal operation)

The device idles when there is no acquisition or entry in process. In idle mode, it is still alert to data received via the serial port. It also monitors the synchronization input. In this mode it responds to through serial input: a hyphen '-', primary address, secondary address and Carriage Return (if set up as master). A low on the synchronization input will plunge the device into acquisition. The ESC character will break any operation and force the device into idle mode.

The Primary Address

When a device receives its primary address over the serial port, it submits the results of its last acquisition, by transmitting this data via the serial port.

The Secondary Address

When the device receives its secondary address, it will enter the following valid hex bytes into work registers until it receives a Carriage Return. Once a Carriage Return is received, the device proceeds with normal operation. During entry, only the hex characters 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F and Carriage Return are valid; all other characters are ignored. If the characters FF plus a Carriage Return are entered following the primary address, the device transmits the contents of the work registers over the serial port.

If a full string is entered into all the work registers, and this string is followed by a correct check sum (that is the sum of all bytes entered excluding the primary address), the device will store this string in EEPROM or permanent nonvolatile memory. This string will be loaded into the work registers whenever the device is restarted.

Once the string has been secured in permanent memory, the device will acknowledge by transmitting the ASCII character + via it's serial port.

Master (Chain Initiator)

A device, which is set up as the master, will transmit a synchronization hyphen ('-') onto the serial network. This will force a synchronized acquisition for all the devices on the network. The Master also sinks the synchronization output low for the duration of the sonic signal transmission. The Master is forced into action if it receives a Carriage Return over the serial port. This feature is useful for closing the chain loop and maintaining continuous operation.

IF (the last device in a chain of network devices has a "Serial Output Termination" byte equal to 'Carriage Return') AND (one device on the network has been set up as the master) THEN the acquisition cycle is repeated indefinitely with a very high sampling integrity.

Note that it is not imperative that one device be set up as a master; the operation can be driven by a PC.

<u>There can only be one master at a time on the same network</u>

Output Format

The output format depends on the way the devices have been set up and the size of the positioning system. For a system with 2 single-channel Pilots and 1 four-channel Pilot chained together, depending on the setup, the output may be as follows:

Pilots	First byte	Sync. Seg.	Beacon Seg. 1		Beacon Seg N
Pilot 1. 1 channel master	Go	####	####		####
Pilot 2. 4 channel slave	Primary Address	#### #### #### ####	#### #### #### ####		#### #### #### ####
Pilot 3. 1 channel slave	Primary Address	####	####		####

Assuming the primary addresses of Pilot 2 and 3 are R and T respectively, for a two-Beacon system the string outputted will be similar to the following:

-#### #### #### R#### #### #### #### #### #### #### #### #### #### #### ####
T#### #### #### (CR)

represents the 16 bit hex value.

Serial Network Introduction

There are two network options available for Hexamite devices (with the exception of the HX900L and HX900B). These are RS485 (recommended standard 485) or the Hexamite serial I/O.

RS232 to USB

RS232 ports are disappearing from modern laptops. It is however possible to use the USB port. The photograph on the right shows the RS232USB cable. This cable allows the computer to communicate with all hexamite products through the USB port.

The Serial I/O is low cost, single ended, and the nature of communications is simplex. Data is both transmitted and received through a single wire (plus return). The serial I/O line must be in the state of high impedance if data is not being transmitted. The longest distance between any two devices on the network should not exceed 20 meters. Maximum number of Hexamite devices per Serial I/O line should be less than 175, however, this can be increased on request. The HX9RS232 serial cable links the Serial I/O to RS232 port on a PC or a terminal.

Serial I/O Network to RS232

Figure S1 illustrates how a number of devices can be connected via HX9RS232 serial cable to a PC. There is a power tap on the HX9RS232 that can be used to provide power to a network of devices. This setup is for a short distance communication no further than 20 meters.

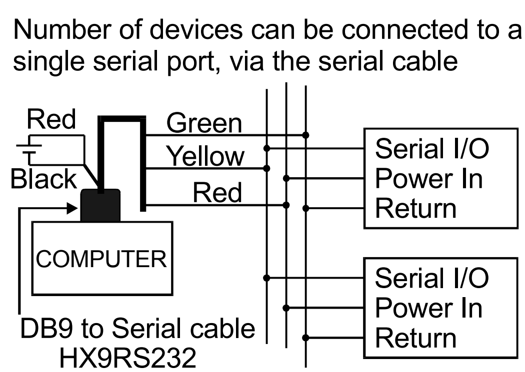


Figure S1

Adding microcontrollers to the serial I/O

Figure S2 illustrates how a Microcontroller can be connected to a Hexamite serial network (serial I/O). Any Microcontroller can use the receive input Rx to monitor the network. If the Microcontroller is to transmit onto the network, the Tx line needs to be in high impedance mode when the Microcontroller is not transmitting. This is readily achieved when using Atmel AVR Microcontrollers' UCR.3. The Tx pin should be set up as input using the data direction registers. The serial transmission should be turned on only during transmission by setting, and turned off after transmission by clearing the UCR.3. The same can be achieved with the Microchip PIC by setting and clearing the TXEN bit.

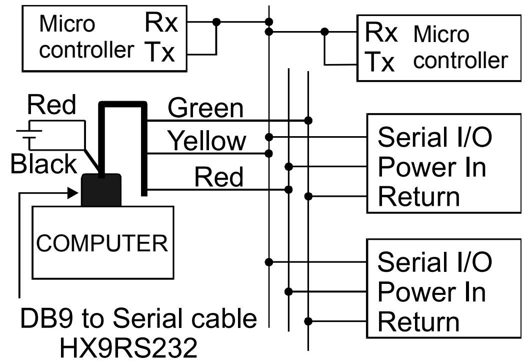


Figure S2

The RS485 is designed for long distance multidrop communications on lines many kilometers in length. Up to 128 Hexamite devices can be applied per network. If communications is needed for more devices, a repeater or repeaters should be used.

RS485 network to RS232

Figure S3 illustrates how a network of devices can be connected using RS485. The RS485 is a long-range communications facility, which allows kilometers between devices.

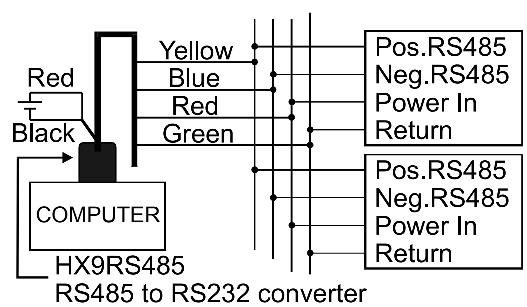


Figure S3

Serial I/O to RS485

Figure S4 illustrates how a serial I/O network can be linked to a computer via long distance RS485 connection to the HX485IO and the HX9RS485. The output pin on the external microcontroller must go high when the microcontroller transmits data.

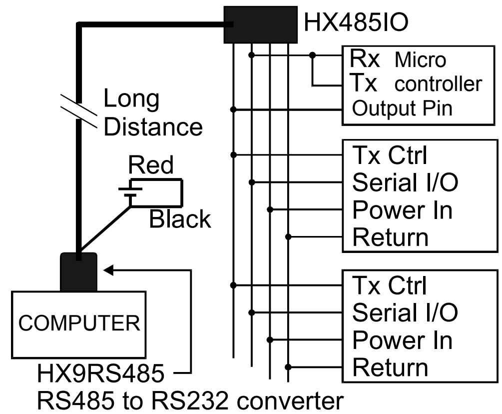


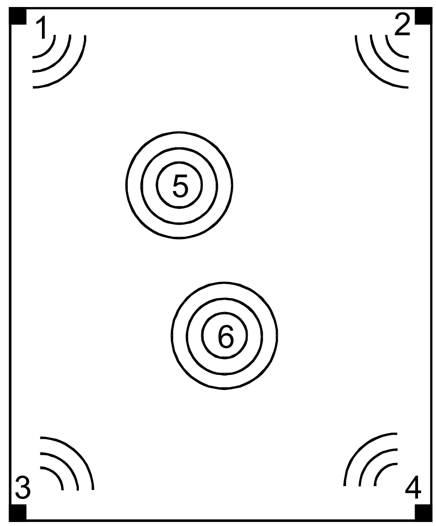
Figure S4

The communication parameters for the Hexamite Positioning Devices are:

19200 baud, 8 bit, 1 stop bit, no parity. No Xon/Xoff handshaking

Application

The illustration in the example below is of a 6 point system, using 6 Hexamite Positioning Devices. There is no fixed limit for the size of the system in terms of points. Point 1, 2, 3 and 4 are shown as fixed points in the corner of the enclosed area on the right; points 5 and 6 may be thought of as moving points. Or points 5 and 6 can be stationary and the perimeter moving in relation to the two. Any setup is possible. Any point in the system can be configured as either a Pilot or a Beacon. The system can be setup within an enclosed area or in open spaces. Hexamite Positioning Devices operate in the ultrasound range around 40KHz with an operating range to about 14m (absolute maximum) per point in the system (other frequencies and ranges are available). A number of devices can be setup within the space monitored to increase the overall range.



The Hexamite Ultrasonic Positioning System is synchronized. Synchronization is achieved by connecting the devices together, or by remote means such as radio, light, or sound. Hexamite Positioning Devices allow synchronization via serial input (RS485 Serial I/O) or by sound (ultrasound). In the case of a **tracking system,** where points 1, 2, 3 and 4 are fixed Pilots and points 5 and 6 are moving Beacons, points 1, 2, 3 and 4 would be connected together via RS485, and one or all of the fixed devices would be used to synchronize 5 and 6 with the built in sonic synchronization feature.

A guidance system consisting of a single Pilot, where the Pilot synchronizes the Beacons using ultrasound, is easily accomplished. The situation gets more complex if 5 and 6 are set up as Pilots guided by 1, 2, 3 and 4 set up as Beacons. This is particularly true if the Pilots are not connected together. If Pilot 5 is used to synchronize the Beacons using the built in sonic synchronization feature, then Pilot 6 doesn't know when the timing cycle starts. If there is only one Pilot being guided by the Beacons, sonic synchronization is not a problem. If there are multiple mobile Pilots guided by a system of Beacons, ultrasound should not be used for synchronization.

Any Pilot can be configured as the master. The master initiates the timing or distance acquisition cycle of the whole system by transmitting a synchronization signal at the beginning of the cycle. At the end of the cycle, all the Pilots transmit their positioning data one after another over the serial network.

HX944M Application Consideration

The first Beacon zone is the only zone a Pilot displays when a device is configured as follows:

Q 09 0D 01 xx xx xx

or

Q 11 0D 01 xx xx xx

or

Q 01 0D 01 xx xx xx

[(xx) Means: don't care]

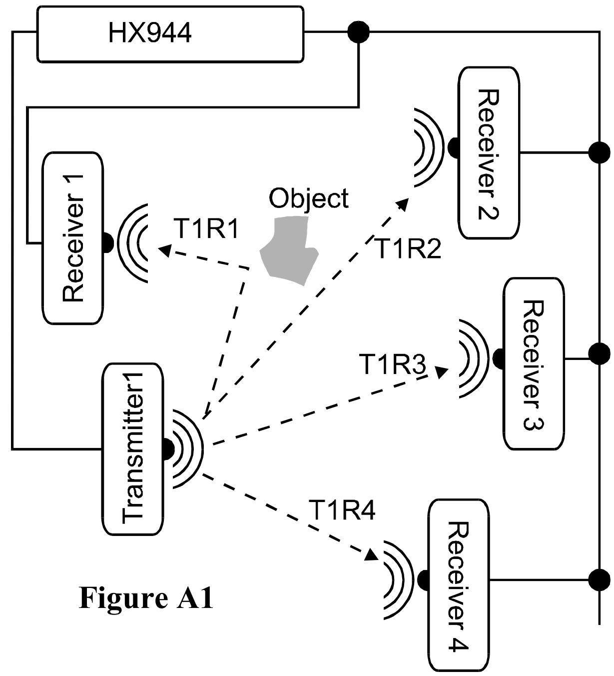


Figure A1

If a 4-channel device like the HX944M is set up similar to that shown in Figure A1, the Q 09 string setup will transmit the following data form over the serial lines.

T1R1 T1R2 T1R3 T1R4 (CR)

The HX944 responds to the first signal it receives and outputs a value proportional to the distance to it. It doesn't matter where the signal came from, whether from a Beacon or an echo of an object. The Hx900 series base their operation partially on the fact that echoes always arrive behind the direct line of sight signal. T1R2, T1R3 and T1R4 will all hold the line of sight distance to the transmitter. Receiver 1 is not in the line of sight and T1R1 will hold a value proportional to the distance from the transmitter to the echo object plus the distance from the object to receiver1.

The Q 11 and Q 01 setups will yield similar results, but these setups include other chained devices in the result string as well.

Figure A2 shows the types of connections to a transmission channel and a receive channel. For a receiver, a shield is required. It is possible to serial connect more receivers on a single receive channel to obtain a higher level of omni-directionality. Two receivers joined back-to-back and serially connected to a receive channel will enable reception front and back. The same goes for the transmission channel; transmission front and back can be achieved similarly. Multiple transmitters on a single channel should be parallel connected. Transceivers are equally good for reception and transmission, and can replace transmitters and receivers where needed. It should be noted that there is a load condition cost for multiple sensors per channel, and the number of sensors used is at the user's discretion.

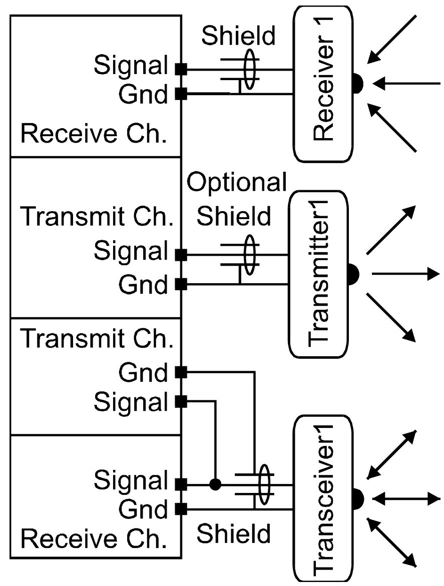


Figure A2

Small Room Syndrome

When there direct line of sight is poor (i.e. the angle θ becomes critically small) or non-existent, the direct line of sight signal may become so weak that it isn't registered. In this case, echoes from walls may cause problems, particularly if the enclosed perimeter is much smaller than the maximum range of the system. As seen in the figure A3, the distance l1 may be substituted by the distance l2 + l3 if the angle becomes very small. The critical angle depends on the distance from the sensor source S. The closer the pickup B is to the source, the smaller the critical angle. In the case of A, there is no line of sight, therefore the distance measured may become d1 + d2 depending on the size of the confine. Close to the sensor S, the critical angle is only a few degrees, but at the outer range limit, the angle is about 90 +/- 20 degrees.

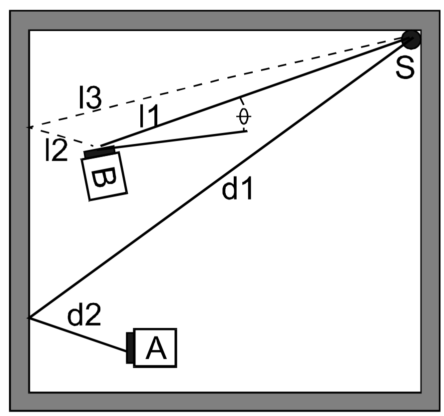


Figure A3

Distance Calculations

When sonic synchronization is used between remote devices, the time of flight of the synchronization signal must be taken into account.

Figure A4 shows a transmitter and a receiver located at a distance from HPD Beacon. The Transmitter synchronizes the Beacon. The total distance calculated by the HPD Pilots is therefore TX>>HPD + HPD>>RX. In the case where many transmitters are used to synchronize the Beacons, the transmitter closest to the Beacon always synchronizes the Beacon

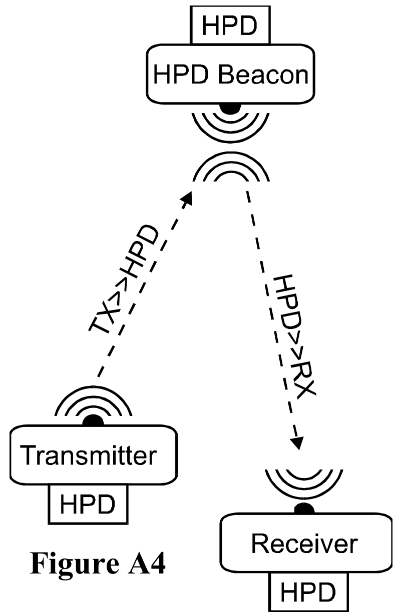


Figure A4

In figure A5 all the transceivers are used to transmit the synchronization signal. To determine the actual distance to each transceiver, find the lowest value in the data string. Once the lowest value, which is HPD<>TC3, is determined, then the actual distance is

Actual Distance (HPD>>TC3) = 0.5 * HPD<>TC3.

When the shortest distance is known, the rest of the distances can be determined.

TC3>>TC1=HPD>>TC1 - 0.5 * HPD<>TC3

and

TC3>>TC2=HPD>>TC2 – 0.5 * HPD<>TC3

It is advantageous to have all transceivers attempt to synchronize the remote Beacon. If synchronization does not take place, no distance is measured. If only one transceiver is used to synchronize, it may or may not be close enough to the Beacon and may or may not activate the Beacon.

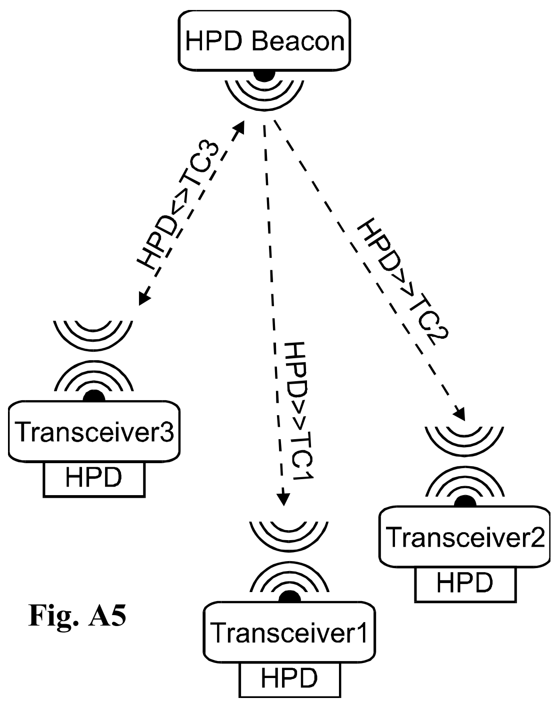


Fig. A5

The distance data from the HPD represents the time of flight of the signals. The timer timing the signals, increments every 2 microseconds. Increments are 500,000 per second. Sound travels at fixed speed, about 344m/s @ 25 degrees C. The equation for calculating distance is:

Distance = K + (C * Increments) / N

Where

C = Speed of Sound
N = Increments per Second
K = calibration correction (increases by fraction of a millimeter per meter)

The increment data from the HPD is presented in hexadecimal. Assuming the distance data HPD>>TC3 = 1C88, the conversion to decimal is as follows:

Increments (HPD>>TC3) = $1x16^3 + Cx16^2 + 8x16 + 8 = 4096 + 3072 + 128 + 8 = 7304$

Distance = 344 (m/s) x 7304 (increments) / 500000 (increments per second) = 5.025 m

Four Point Tracking System Example 1

Figure A6 shows a setup for a 4-point tracking system. The Hexamite Positioning Devices HPD1 and HPD2 are configured as Pilots. The Hexamite Positioning Devices HPD3 and HPD4 are configured as Beacons (see software configuration). Assuming HPD1 and HPD2 have primary addresses H (48) and J (4A) respectively, the system is set up as shown in the table below.

(Please refer to the software configuration section).

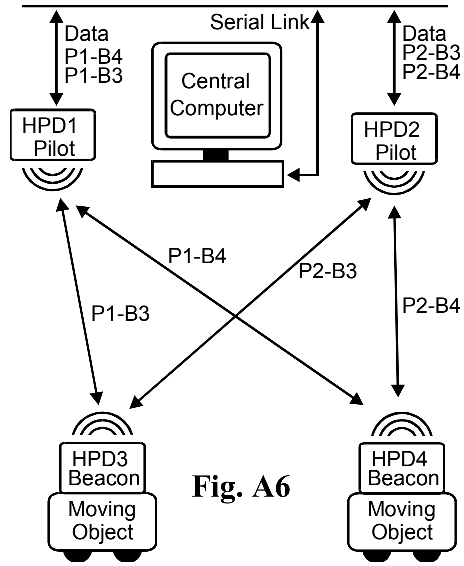


Fig. A6

Hexamite Positioning device 1 is set up as master and the sonic synchronizing device. At the end of the acquisition cycle, the master transmits the distance P1-B3 and the distance P1-B4 over the RS485 serial line. At the end of the transmission, the master calls the device with primary address (4A). This will force HPD2 to transmit the distance P2-B3 and P2-B4 followed by a 'Carriage Return' over the serial line. Note that only HPD1 transmits a synchronization signal to the Beacons. The Carriage Return forces HPD1 to initiate another Position Acquisition cycle. The distance data reported by HPD1 is actually twice the distance P1-B3 and P1-B4. It is the distance the sonic synchronization had to travel to reach the Beacons plus the distance the response signals traveled from the Beacons. Hence the actual distance value submitted by HPD2 is [P1-B3] + [P2-B3] and [P1-B4] + [P2-B4]. The position acquisition time of this 4-point system is 0.264 + 0.0078 seconds.

X in the table means that the device ignores this byte.

DEVICE	PCB bits set	TB	NBB	BDB
HPD1	4 and 0	4A	2	X
HPD2	None	0D	2	X
HPD3	7 and 0	X.	2	1
HPD4	7 and 0	X.	2	2

Given that the primary addresses of HPD1= H, HPD2=J, HPD3=L and HPD4=N, and given that HPD1 and HPD2 are on a network, then the setup strings for the application example1 above can be:

O 81 xx 02 01 00 xx (xx means don't care)
M 81 xx 02 02 00 xx (don't forget the checksum)
K 00 0D 02 xx 00 xx
I 11 4A 02 xx 00 xx

Other application examples in this document discuss how data is created when both Pilots transmit the synchronization signal.

Four Point Guidance System Example 2

Figure A7 illustrates a setup for a 4-point guidance system. The Hexamite Positioning Devices HPD1, 2 and 3 are configured as Beacons. HPD4 on the mobile object A is configured as a Pilot. The system is set up as shown in the table below

HPD3, the Pilot, has been set up to emit a sonic synchronization signal and is the only Pilot. It will synchronize all Beacons in range. It will transmit continuously through its serial port the distances B1-P4, B2-P4, and B3-P4, plus the distance the sonic synchronization signal had to travel.

The distance transmitted is twice the actual distance from the Pilot to each Beacon. If there is more than one Beacon using the same Beacon Designation Byte (BDB) within range of the Pilot, the Pilot will submit the distance to the closest of the identical Beacons. This allows a large number of Beacons to be set up within and outside the monitored perimeter without sacrificing the Position Sampling Rate. The Position Acquisition Time of this 4-point system is 0.528 + 0.0052 seconds.

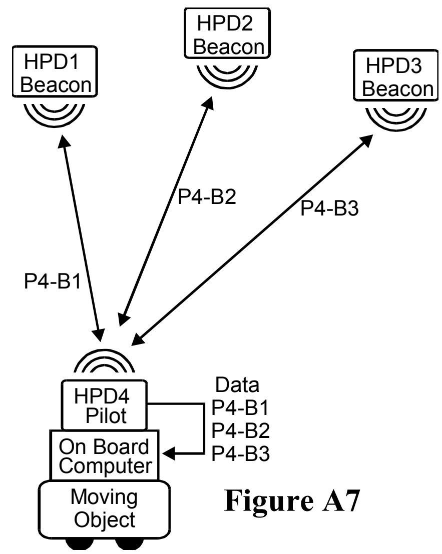


Figure A7

DEVICE	PCB bits set	TB	NBB	BDB
HPD1	7 and 0	X	3	1
HPD2	7 and 0	X	3	2
HPD3	7 and 0	X	3	3
HPD4	3 and 0	0D	3	X

Given that the primary addresses of HPD1=H, HPD2=J, HPD3=L, and HPD4=N, then the setup strings can be:

I 81 xx 03 01 00 xx (xx means don't care)
K 81 xx 03 02 00 xx (don't forget the checksums)
M 81 xx 03 03 00 xx
O 09 0D 03 xx 00 xx

Six Point Guidance (Tracking) Radio Link Example 3

Figure A8 illustrates a 6-point system linked using wireless means. This setup enables virtually instantaneous synchronization of all Positioning Devices in the system. If the wireless link is sophisticated and is enabled for data communication, then each Positioning Device can be set up between Position Acquisition cycles. In this case, the system is both a guidance system and a tracking system since all positions can be extracted out of all Positioning Devices, i.e., HPD1 can be configured as Pilot through the wireless network hence it will be able to report its position relative to other devices. The wireless link can be realized using light or radio, and positioning data submitted by the Pilots is the actual distance + the time it took for the synchronization signal to travel to the Positioning Device (speed of light). This error is insignificant. Again, the Position Sampling Rate is based on the number of Beacons in the system. For the illustration on the right, as it is set up, it is 0.66 + 0.008 seconds.

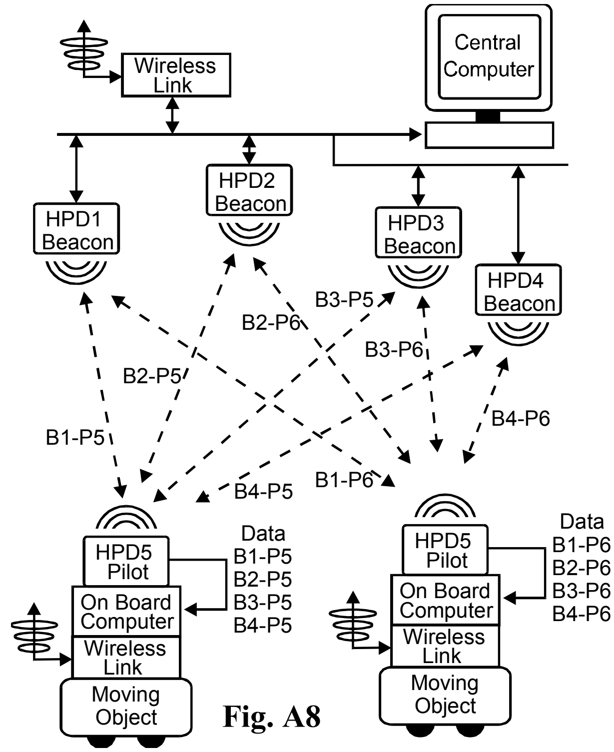


Fig. A8

Guidance and Orientation Example 4

Figure A9 shows a moving vehicle. The HX944M set up as the Pilot is mounted on the vehicle. The two Beacons can consist of any Hexamite Positioning device, HX900L, HX900B, HX944M, HX900, or even another HX944M. Any 40kHz Hexamite sensors can be used as sensors 1, 2, 3 and 4. In the illustration, Transmitter 1 (T1) and Receiver 1 (R1) are setup to face each other. The HX944M will report the distance from t1 to r1. If this distance is fixed, the speed of sound can be calculated for reference. This set up achieves high absolute accuracy in any temperature and humidity conditions. If there is nothing to block line of sight from R1 to the Beacons, R1 will also pick up the distance (B1-P1) and (B2-P1). Due to the extreme angle between B1 and P4, this distance is not likely to be reported by the HX944M.

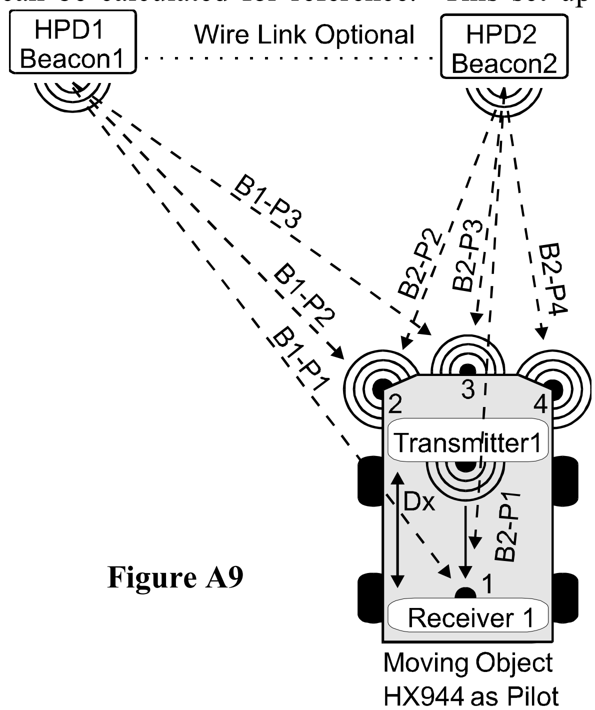


Figure A9

Assuming there are no other Hexamite devices in network group operation with the HX944M and that the HX944M has the primary address P, then the following string will set the HX944M up for this operation.

Q 09 0D 03 00 04 00 1D

Device Q is set up as Pilot in a 2 point system NBB=Beacons +1=03, the designation byte doesn't apply. Noise Suppression=04 (may not be necessary). 29 is the checksum

Assuming B1 has primary address H and B2 has primary address J then

I 81 0D 03 01 00 00 92
K 81 0D 03 02 00 00 93

This will set Hexamite positioning device HPD1 and HPD2 up as Beacon 1 (B1) and Beacon 2 (B2) respectively. Once the strings are loaded into the devices with the checksums 92 and 93, the operation will commence automatically.

During the operation the HX944M will continuously transmit the following format:

TxR1 TxR2 TxR3 TxR4 B1P1 B1P2 B1P3 B1P4 B2P1 B2P2 B2P3 B2P4 (CR)

The string is terminated with CR ('Carriage Return' or 0D) as specified in the setup string. The above string is symbolic; the real data is going to look more like

0133 0000 0000 0000 12CD 12C0 1139 0000 3111 4032 4322 2333 (CR)

TxR1 is the distance from R1 to the nearest detectable transmitter, it doesn't matter from which transmitter the reference signal is transmitted; the nearest detectable transmitter is the key. The data above is fictional, to indicate what sort of data is read using a serial COM terminal program. Assuming the line of sight angle is too large for the B1-P4, no signal is likely to be picked up so the data will be 0000. The HX944M will transmit this data continuously until stopped using the 'ESC' character.

TxR2, TxR3, and TxR4, could actually contain the distance calculated to the nearest object if no sensor is directly facing the respective receiver. If this is the case, this data should be ignored.

Note that in this application example, the Beacons are fixed and the Pilot is moving. The same setup can be used for a situation where the HX944M is stationary tracking the position of the moving Beacons.

Low Cost Guidance and Orientation

(Using HX944M as Beacons)

Figure A10 shows the HX944M set up as Beacons. In this example there are 16 distance values from Beacon sensors to Pilot sensors. The data transmitted over the serial lines by the HX944M is as follows:

TxR1 TxR2 TxR3 TxR4 B1P1 B1P2 B1P3 B1P4 B2P1 B2P2 B2P3 B2P4 B3P1 B3P2 B3P3 B3P4 B4P1 B4P2 B4P3 B4P4

Wires must connect the sensors to the HX944M Beacon. The length of the wires has an effect on the system's performance. If in the example on the right, the primary address of the HX944M that is shown as the Beacon is R, then the setup string to turn the device into Beacons is:

S 81 0D 05 00 00 00 93 … 93 is the checksum

The Pilot must be set to fit this system of Beacons. Assuming the Pilot has the primary address T, the set up string can be:

U 09 0D 05 00 00 00 1B … 1B is the checksum

It is possible to add more HX944M units to both the Beacon setup and the Pilot setup. If one more HX944M is added to the Pilot setup and if T is set up as master (see Master [Chain Initiator] section) and the new device has the primary address V, then the following strings are submitted to the device. A string of 40 distance values will be transmitted over the serial lines.

W 01 0D 05 00 00 00 13 … 13 is the checksum
U 11 56 05 00 00 00 6C … 6C is the checksum

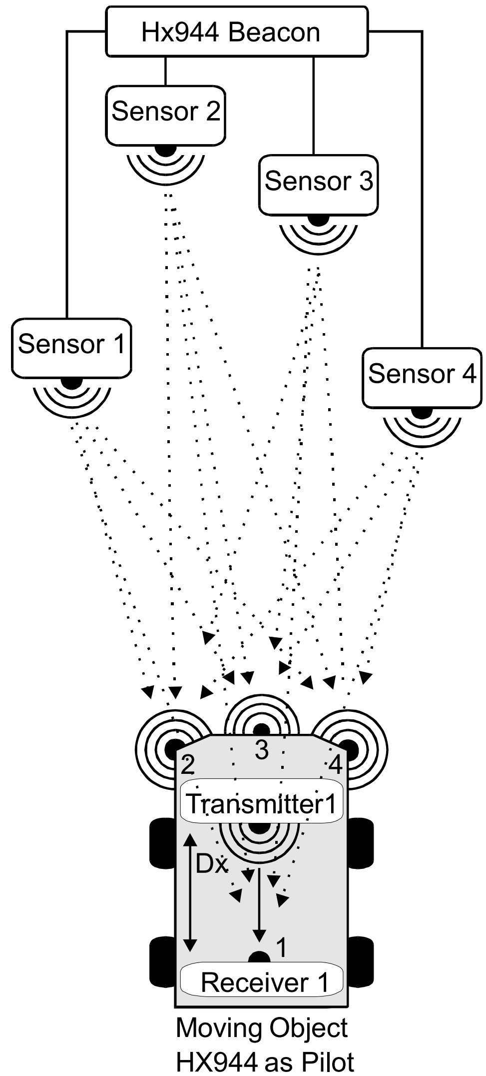


Figure A10

The results are achieved at no cost to sampling rate. Before the add-on, 20 distance values were received per unit of time. With the add-on unit, 40 distance values are received per unit of time.

The data for this setup transmitted over the serial lines is similar to the following:

- TxR1 TxR2 TxR3 TxR4 B1P1 B1P2 B1P3 B1P4 B2P1 B2P2 B2P3 B2P4 B3P1 B3P2 B3P3 B3P4 B4P1 B4P2 B4P3 B4P4 [V] TxR1 TxR2 TxR3 TxR4 B1P1 B1P2 B1P3 B1P4 B2P1 B2P2 B2P3 B2P4 B3P1 B3P2 B3P3 B3P4 B4P1 B4P2 B4P3 B4P4

If no signal is detected by any sensor, then the following data is transmitted over the serial lines:

– 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 V0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 (CR)

If another Beacon is added to Beacon S (secondary) for the same system, the setup strings would have to be, assuming the new device is X (primary):

Y 81 0D 09 00 00 00 97
S 81 0D 09 00 00 00 97
W 01 0D 09 00 00 00 17
U 11 56 09 00 00 00 70

In this case, a total of 80 distance data would be received over the serial lines, and there is a cost to the acquisition time since the unit was added to a Beacon.

Indefinite Range Guidance Along a Path

Figures A11 and A12 illustrate how guidance may occur along a path. Beacons 1 and 2 guide the vehicle initially. The Pilot always locks on the signal arriving first, and it ignores signals arriving later. Even if Beacon 3 or 4 is picked up in the initial position, these signals are ignored. Line of sight is required for positioning. Once Beacon 1 and 2 are passed, the Pilot on the vehicle no longer receives signals from Beacon 1 and 2. Both position and orientation can be calculated anywhere on the path. Beacons can be placed along a very long path in this manner and guide the vehicle.

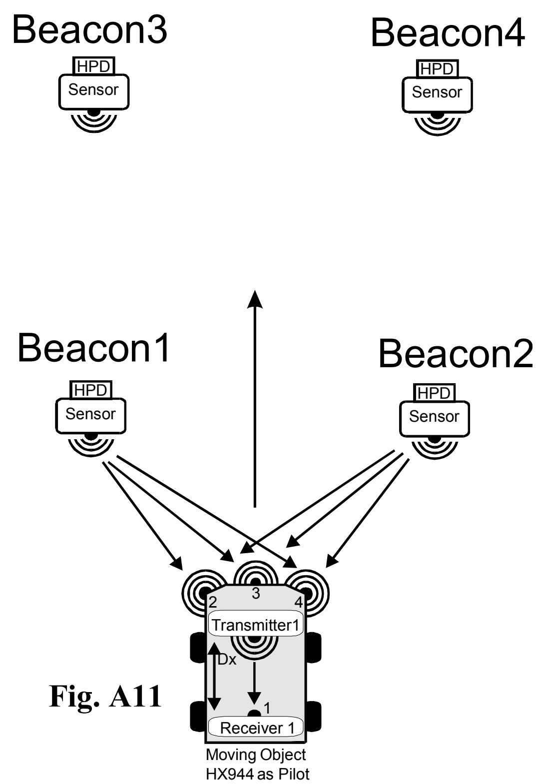


Fig. A11

Once the vehicle passes Beacons 1 and 2, as illustrated in Figure 12, Beacons 3 and 4 take over the guidance. It is not necessary to use the HX944M as a Pilot on the vehicle. Two HX900L or HX900 placed on the front corner of the vehicle, and connected together by the synchronization wire, will do just as well. I.e. sufficient to report both position and orientation.

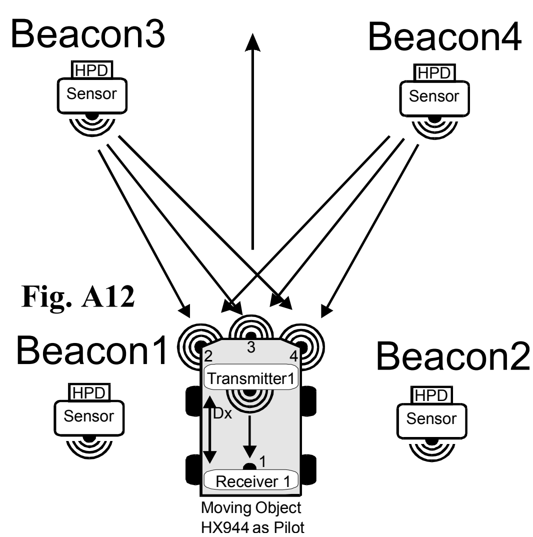


Fig. A12

HX900 Ultrasonic Positioning Device (HPD)

Application

- Ultrasonic Tracking and Guidance Systems
- Machinery and Automation Spatial Position Feedback
- Object Locator Systems.

Features

- Range up to 14m
- Max. Resolution 0.7mm
- Environmental Noise Immunity

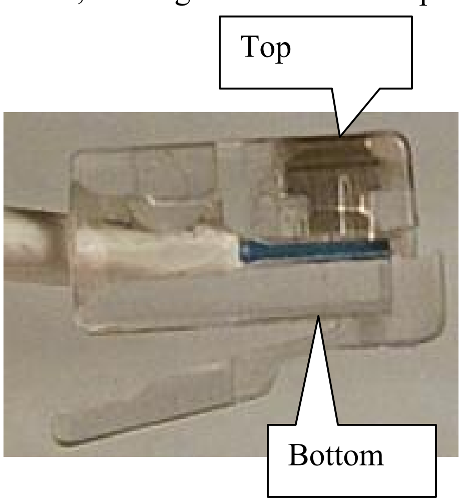
Size: 1.5" x 3" x 13/16" (20 x 80 x 40 mm)

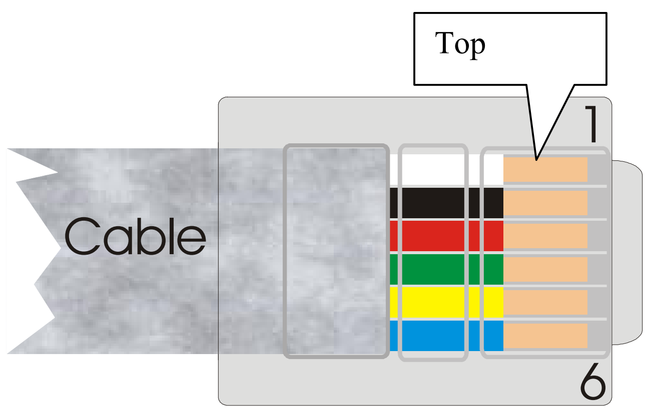
HX900 Description

The HX900 is designed to operate as a point (HPD Hexamite Positioning Device) in a multipoint multidimensional positioning system. It can be setup as a Pilot or a Beacon via serial I/O wire connectors on the device. This device has construction that makes it best for multipoint fixed applications linked via RS485 network. The detection angle for the HX900 is 130 degrees at a distance of 6 meters. At a distance of 8 meters this angle is 75 degrees. These angles are measured HX900 to HX900.

<u>HX900 replaces the old HX900M, HE900M and HE900M1</u>

The photograph below shows a typical FCC RJ11 plug, these plugs are commonly used with telephones. Below and to the right is a figure that shows the contacts numbered from 1 to 6, looking down from the top as shown in the photograph.





Wire Configuration HX900RS485			
Contact	**Wire color**	**Wire function**	Electrical Specs
1	White	Reset	0 - 7 Vdc *
2	Black	Power Input (Positive)	8-16Vdc
3	Red	RS485 Positive **	+/- 7V
4	Green	RS485 Negative **	+/- 7V
5	Yellow	Ground / Return (Negative)	0V
6	Blue	Reserved	0 – 7 Vdc *
** Current forced through the Mode and Reset pins should never exceed 20mA*			
*** To connect the HX900RS485 to a RS232 port on a computer, a RS485 to RS232 converter is required. RS485 is suited for long distance communication.*			
Wire Configuration HX900ARS485			
Contact	**Wire color**	**Wire function**	Electrical Specs
6	Blue	Reset	0 - 7 Vdc *
5	Yellow	Power Input (Positive)	8-16Vdc
4	Green	RS485 Positive **	+/- 7V
3	Red	RS485 Negative **	+/- 7V
2	Black	Ground / Return (Negative)	0V
1	White	Reserved	0 – 7 Vdc *
** Current forced through the Mode and Reset pins should never exceed 20mA*			
*** To connect the HX900ARS485 to a RS232 port on a computer, a RS485 to RS232 converter is required. RS485 is suited for long distance communication.*			

Wire Configuration HX900BSIO, HX900LSIO			
Contact	**Wire color**	**Wire function**	Electrical Specs
1	White	Reset	0 - 7 Vdc *
2	Black	Power Input (Positive)	8-16Vdc
3	Red	Serial I/O **	0 – 7 Vdc *
4	Green	Mode	0 - 7 Vdc
5	Yellow	Ground / Return (Negative)	0V
6	Blue	Reserved	0 – 7 Vdc *
** Current forced through the Mode and Reset pins should never exceed 20mA*			
*** Devices with serial I/O come with a serial cable (HX9RS232) that connects the units directly to a standard RS232 port on a computer. Serial I/O is not suited for long distance communication. The serial I/O cable should not exceed 10 meters.*			

Mode (HX900BSIO & HX900LSIO)

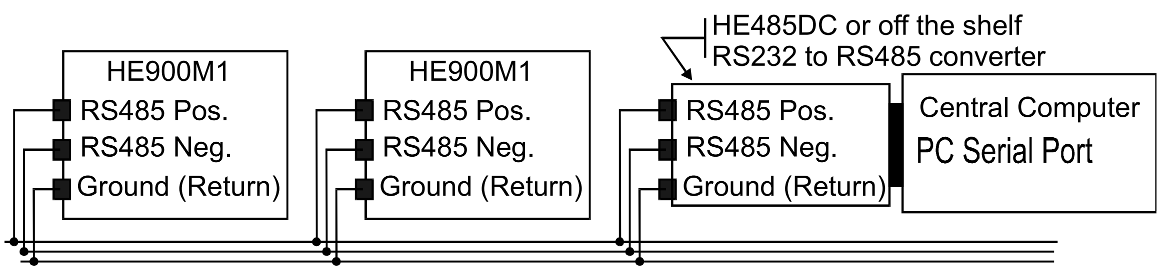
When the mode wire is open or at 5 volts, the HX900 enters energy saving mode (see below) if it is set up as a Beacon. In this mode the device sleeps until it encounters ultrasonic signals. It can take the device up to a minute to become fully alert when it is awaken by an ultrasonic signal. If the device is set up as a beacon and this pin is open, it may not be possible to contact the device via the serial lines.

If the mode wire is grounded, the device does not go to sleep when it is configured as a beacon and is always fully alert.

If the device needs to communicate with a PC, make sure this wire is grounded if the device has been configured as a beacon.

Electrical Specification		
Parameter	Value	Units
Voltage Supply	7 - 16	Volts
Current consumption	12	mA
Sonic Transmission @16 V dc	40	KHz
Transmission Level @16 Vdc	125	DB
Range @ 16 Vdc	16	meters

The illustration below shows how HX900RS485, HX900ARS485 and HX900M1 positioning devices may be connected to a RS485 network. The wires connecting the devices can be up to 10 miles long. The network is plugged into the serial port of the central computer through a RS232 to RS485 converter; these are commercially available. Hexamite supplies the HE485DC designed to work for this type of network only. Refer to the serial networking section for networking of serial I/O, (HEXIO).



The HE900-RS485 is compliant with recommended standard 485. An RS485 to RS232 converter is required if the PC is to be used to control and monitor operations.

The detection angle for the HX900B is 120 degrees at a distance of 6 meters. At a distance of 8 meters this angle is 70 degrees. These angles are measured using the HX900 as Pilot.

Low Power Devices

Two low power devices HX900L-SIO, HX900B-SIO and HX900R are available. The HX900L-SIO is a low power device with supply voltage requirements from 3Vdc to 7Vdc. The HX900B-SIO has an internal battery that can be charged through the Power Input. And the HX900R comes with a replaceable battery. The HX900R has no I/O pins it is set up as a beacon and this setting cannot be changed. The single lithium battery lasts for years while the device sleeps, and it will sustain full operation for months. All other functions are identical to the basic HX900 device.

Wire Configuration HX900L-SIO			
Contact	**Wire color**	**Wire function**	Electrical Specs
1	White	Reset	0 - 7 Vdc *
2	Black	Power Input (Positive)	3 – 7 Vdc ***
3	Red	Serial I/O **	0 – 7 Vdc *
4	Green	Not Connected	
5	Yellow	Ground / Return (Negative)	0V
6	Blue	Mode	0 – 7 Vdc *
** Current forced through the Mode and Reset pins should never exceed 20mA*			
*** SIO (Serial I/O) devices come with a serial cable (HX9RS232) that connects the units directly to a standard RS232 port on a computer. Serial I/O is not suited for long distance communication. The serial I/O cable should not exceed 10 meters.*			
**** There is no direction diode built into the HX900LSIO, if the power input is reverse polarized the device will be damaged.*			

The detection angle for the HX900LSIO is 120 degrees at a distance of 6 meters. At a distance of 8 meters this angle is 60 degrees. These angles are measured using the HX900 as Pilot.

Wire Configuration HX900B-SIO			
Contact	**Wire color**	**Wire function**	Electrical Specs
1	White	Reset	0 - 7 Vdc *
2	Black	Power Input and Battery Charge (Positive)	4.5 – 7 Vdc
3	Red	Serial I/O **	0 – 7 Vdc *
4	Green	Not Connected	
5	Yellow	Ground / Return (Negative)	0V
6	Blue	Mode	0 – 7 Vdc *
** Current forced through the Mode and Reset pins should never exceed 20mA*			
*** SIO (Serial I/O) devices come with a serial cable (HX9RS232) that connects the units directly to a standard RS232 port on a computer. Serial I/O is not suited for long distance communication. The serial I/O cable should not exceed 10 meters.*			

Specification HX900L-SIO		
Parameter	**Value**	**Units**
Voltage Supply (No Battery)	3 – 7	Volts
Max Current consumption while active @3V	2	mA
Average Current while Active @3V	1.5	mA
Current consumption while in deep sleep @3V	0.07 (typical)	mA
Sonic Transmission	40	kHz
Transmission Level	113	DB
Range @ 3V	9	Meters

Specification HX900B-SIO		
Parameter	**Value**	**Units**
Charge Voltage	4.5 – 6	Volts
Voltage Supply	4.5 – 6	Volts
Sonic Transmission	40	KHz
Transmission Level	113	DB
Range	10	Meters

Energy Saving Mode

If the device is set up as beacon and the Mode pin is open, the device is in energy saving mode. If no ultrasonic activity is detected the device goes progressively into deeper and deeper sleep mode. If no activity is detected for 30 seconds the device enters deep sleep where it consumes between 30 and 100 micro amps it consumes. It can take up to 60 seconds to bring the device out of deep sleep. In active mode the average consumption is about 2mA.

	Range @ 45^o	
HX900L-SIO	11m	Can be set as pilot or beacon, low external power
HX900B-SIO	10m	Can be set as pilot or beacon, low external power with internal rechargeable battery.
HX900R	10m	Fixed as beacon, internal replaceable battery
HX900-SIO	13m	Can be set as pilot or beacon
HX900-RS485	13m	Can be set as pilot or beacon. Requires RS485 to RS232 adaptor (see HX485DC)
HX900ARS485	13m	Can be set as pilot or beacon. Requires RS485 to RS232 adaptor (see HX485DC)

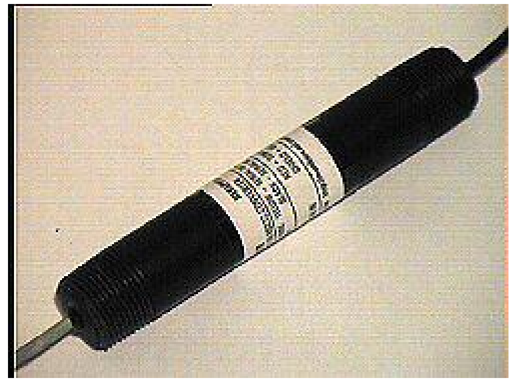
HX911P Single Channel Ultrasonic Positioning Device

Application

- Ultrasonic Tracking and Guidance Systems
- Machinery and Automation Spatial Position Feedback
- Rugged Enclosure IP68 Compliant

Features

- Range up to 14m
- Max. Resolution 0.7mm
- Environmental Noise Immunity

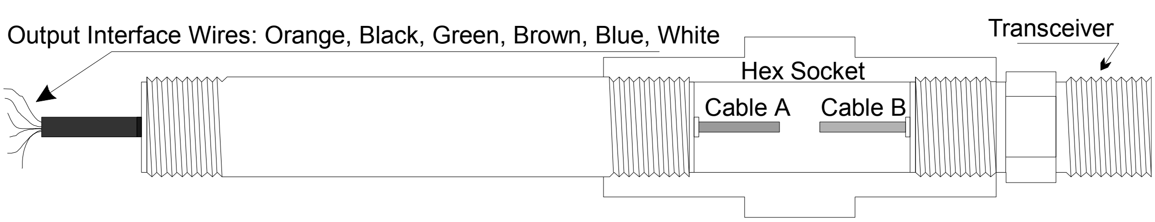


HX911P Description

The HX911P is designed to operate as a point in a multipoint multidimensional positioning system. It can be setup as a Pilot or a Beacon via serial I/ O pins on the back of the device. This device is designed for operation under harsh industrial conditions. It has an RS485 interface by default, but it is also available with RS232 interface.

Modular Configuration

The HX911P is enclosed in a standard 3/4" - 20 PVC pipe. Threads are NPT American standard national pipe threads. Mounting accessories are widely available. Most hardware stores carry variety of suitable fittings. By wiring the components together inside the tube as shown in the illustration below, a solid rugged customized watertight system can be constructed for virtually any application, fast and with relative ease. Sensors like the HE240TR, HE240TXRX, HE240TR, HE240TXRX, HE240STR, and the HE240STXRX will all work with the HX911P series.



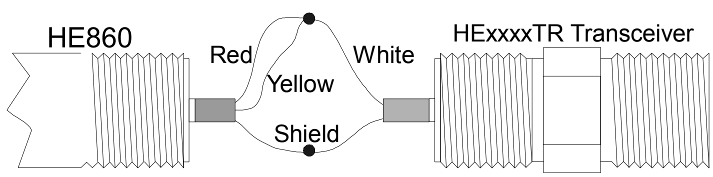
Readily Available Modular Accessories

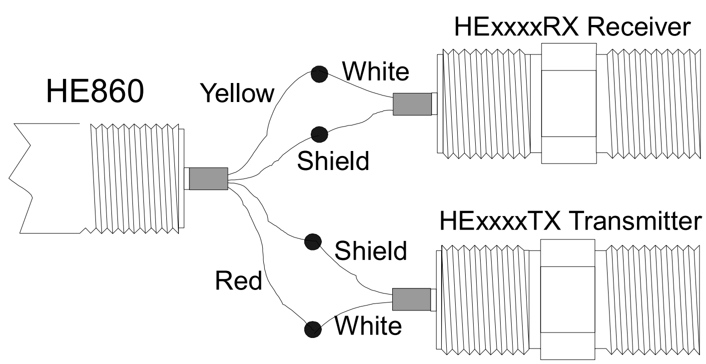
The figure on the right shows some parts readily available from most local hardware stores. The picture shows an HE240STR sensor, straight Hex Socket, and an L-socket. These are heavy-duty chromed brass joints. Many other parts and are available to suit most applications.

The Picture on the right shows an HX911P device and a sensor element HE240TR connected together using an L-shape female to male joint, and a hex socket connects the male side of the L-joint to the HX911P.

The Picture on the right shows an HX911P device and a sensor element HE240STR joined using a straight Hex Socket. It should be understood that it is not necessary to have the HX911P close to the sensor, however, proximity reduces the probability of environmental electromagnetic interference. A long shielded cable can be used to connect the HX911P to the appropriate sensor. These fittings are available from most hardware stores

The illustration below shows how the sensor is connected to the HX911P. The upper image uses the same element for transmission and reception, while the lower unit uses separate elements.



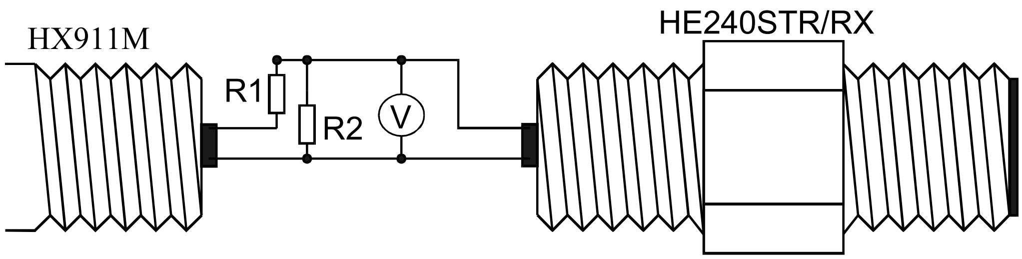


If the **HE240STR** or the **HE240STX** is being used to transmit the sonic wave, the voltage V supplied to the sensor must not go higher than 42V peak to peak for sustained periods. The illustration below shows a voltage divider used to protect the sensor.

The voltage V becomes

V = V(HX911P) x R2 / (R2+R1)

The values for R1 and R2 should be selected so that the voltage V stays beneath 42V peak to peak. If the transmission signal exceeds this limit, the sensitivity of the sensor is gradually diminished and both range and position sharpness is degraded.



HX911P Enclosures PVC, IP68 compliant. Shape cylindrical. Size 0.8" dia., 6" long.

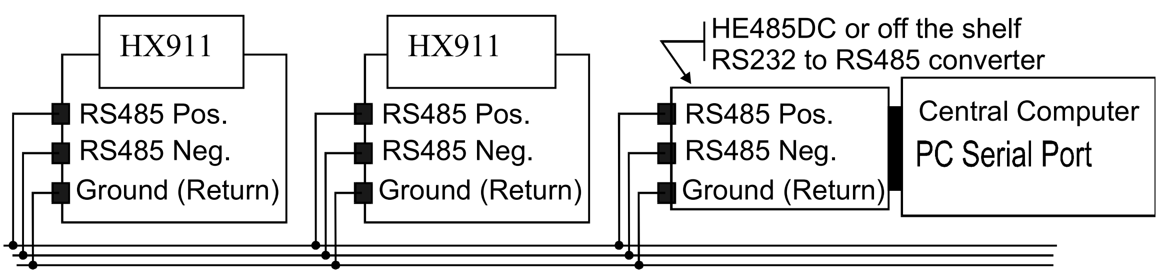
Wire color configuration for the HX911P. Sensor wires cable color gray 2 conductors and a shield	
RED	Sonar out: transmits sonar signal max 60Vp-p
YELLOW	Sonar in: receives sonar signal
SHIELD	Signal return (Ground)
When connecting a transceiver (single element for both transmission and reception) Red and Yellow can be connected together.	

The communication parameters for the HX911P are 19200 baud, 8 bit, 1 stop bit, no parity. No Xon/Xoff handshaking

Control wires cable color black: 6 conductors		
Wire	Direction	**HX911P**
RED	Input	Power 7 to 16Vdc
GREEN	Return	Ground
BLACK	Input/Output	RS485 -
YELLOW	Input/Output	RS485 +
WHITE	Input/Output	Synchronization in/out
BLUE	Input	Auxiliary power
Electrical Specification		
Parameter	**Value**	**Units**
Power	7 - 16	Volts
Average Current consumption	10	mA
Output power, resistive load	10	W(rms)

Never reverse polarize the power input. Do not apply a potential higher than 7V to the Brown and Blue wire. If a current higher than 20mA is forced through the Brown or Blue wire, it may damage the microcontroller.

The illustration below shows how HX911P positioning devices may be connected to a RS485 network. The wires connecting the devices can be up to 10 miles long. The network is plugged into the serial port of the central computer through an RS485 to RS232 converter. These are commercially available. Hexamite supplies the HE485DC designed to work for this type of network only. Refer to the serial networking section for networking of serial I/O, (HEXIO).



HX944M Four Channel Ultrasonic Positioning Device

Application

- Ultrasonic Tracking and Guidance Systems
- Object Orientation and Position
- Spatial Position Feedback

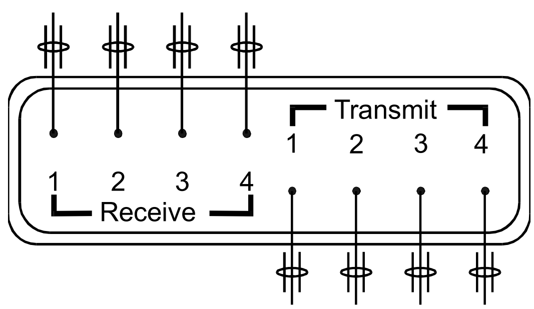
Features

- Range up to 12m
- Max. Resolution 0.7mm
- Compensation for environmental noise
- Size: 1" x 2.8" x 2.8" (30 x 80 x 150 mm)

HX944M Description

The HX944M is a 4-channel positioning device. It can be configured as a Pilot or as Beacons and has separate transmission and reception. If this device is set up as Pilot, it outputs 4 distances to each Beacon. When set up as Beacons, it behaves as 4 wired standard Hexamite Beacons. The HX944M can be joined with more HX944M devices to form a very large positioning array. The device comes with open wires. These can be extended to a needed length. Lengths shorter than 10m per sensor do not cause significant performance degradation. It is up to the user as to how much performance degradation is acceptable as a trade-off for distance between sensors. The transmission and reception channels can be connected together when a single transceiver is used. This device will work with all 40kHz transceivers and sensors sold by Hexamite.

The front panel has 4 transmission channels and 4 receive channels. Shielded cables connect the sensors to each channel. When a transceiver is used, the respective transmission channel cable wires can be connected together. Any Hexamite 40kHz sensor can be connected to these channels.



Control Wires: Function

The *HX944* has four wires connecting it to network and power. Two wires, Orange and Green, provide the unit with power. Two wires, Black and White, facilitate communication with the *HX944*. If the Blue wire is open (not connected) or 5 volts at startup, the default parameters are loaded into the working registers of the device. The default parameters are set for one unit operation, i.e., it is assumed that it is the only device on the network. While default parameters are loaded, the device continuously initiates position acquisition cycles and transmits data acquired during the cycle. This allows the user to test the communication between the *HX944* and the computer, and adjust the communication settings. During normal multidrop network communications, the Blue wire should be grounded to 0V, otherwise there will be a network conflict.

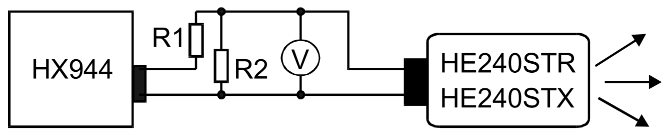
Control wires cable : 6 conductors	
Wire color	**Wire function**
Orange	Power Input
Green	Ground/Common/Return
White	RS485 Positive
Black	RS485 Negative
Brown	Auxiliary Synchronization
Blue	Test/Mode

Brown Wire: Synchronization Input

The device will synchronize on the falling edges of the input signal. If in Beacon mode, the signal on this pin overrides other form of synchronization. If the device is configured as master, this pin outputs the synchronization signal.

Electrical Specification		
Parameter	Value	Units
Voltage Supply	7 - 14	Volts
Max Current consumption	20	mA
Sonic Transmission	40	KHz
Transmission Level	120	DB

If the **HE240STR** or the **HE240STX** is being used to transmit the sonic wave, the voltage V supplied to the sensor must not go higher than 42V peak to peak for sustained periods. The illustration on the right shows a voltage divider used to protect the sensor. The voltage V becomes:



V = V(HX911P) x R2 / (R2+R1)

The values for R1 and R2 should be selected so that the voltage V stays beneath 42V peak to peak. If the transmission signal exceeds this limit, the sensitivity of the sensors is gradually diminished and both range and position sharpness is degraded.

Important: The HX944M is extremely sensitive. When connected to a computer, ungrounded switcher power supplies from laptops and desktop can disturb the HX944M. In the event of interference, make sure any device connected to the HX944M is well grounded. Laptops running on batteries do not disturb the unit while connected.

The illustration below shows how the HX911P positioning devices may be connected to a RS485 network. The wires connecting the devices can be up to 10 miles long. The network is plugged into the serial port of the central computer through a RS485 to RS232 converter. These are commercially available. Hexamite supplies the HE485DC designed to work with this type of network only. Refer to the serial networking section for networking of serial I/O, (HEXIO).