Ultrasonic Positioning

Ultrasound remains the lowest cost positioning option, with respect to accuracy, repeatability and positioning resolution. The line of sight drawback, for ultrasonic positioning may actually be an advantage for some applications. Ultrasound is completely confined to the area in which it operates. This means that neither can it affect operation outside its boundaries, nor can anything outside the boundaries affect it. Operation in one room can be completely separated from operation in nearby rooms. This is also true to an extent for separators in a large hall.

Unlike radio tracking, ultrasound cannot be jammed using an unsophisticated radio transmitter located outside or inside the complex. Multi-path errors are made irrelevant by ensuring a line of sight; the operation is secure and private. Sunlight harmful to infrared systems will not affect ultrasound. With reasonable precautions, ultrasound can be used outdoors as well as indoors.

Tracking Vs Guidance

Tracking refers to a situation where a central device for an example a computer, monitors the position of objects, or moving objects relative to fixed points. When tracking, the moving objects may not be aware of their position

Guidance refers to a situation where moving objects (autonomous), calculate their positions relative to other objects in known positions.

Hx11 is our third generation ultrasonic positioning system, preceded by hx900 and hx5. The Hx11 enables simultaneous fast tracking and guidance. While the positions of moving objects are monitored and logged by a central computer; these same moving objects are aware of their own position. This is possible by combining asynchronous mode, with differential synchronous mode. On the following page we attempt to explain the ultrasonic transaction in layman’s terms, (no need to be fluent with hexadecimal yet).

The HX11X asynchronous mode

The philosophy of the asynchronous operation, involves controlled interaction between a caller and a listener. The simplified explanation below may help understand this interaction. Imagine your name is Peter, and you walk into a dark room. Unable to determine your position you yell out Peter! (we refer to peter as the caller). There is a response out of the dark, and the response is GeorgePeter. Since you have the ability to measure the time your call left you, until the reply arrives, and knowing that sound travels roughly at 344m/s through air. You have a good idea how far away George is. Suppose that a while later, there's a response JohnPeter, you now know how far away John is. If you have a data, that tells you what room John and George are in. And if that data also tells you, that they are in a fixed position, and you know the coordinates. Then you have enough information to determine your two dimensional position. If Jim is also in a fixed known position, and there's a response JimPeter, you have enough information to determine your three-dimensional coordinates. We refer to Jim and George as transponders.

But there may be more callers in the room. John and Jim might also be callers, which you may respond to (in this case you are the transponder). You recognize the response to your own call, because your name is appended to the reply. None of the members of the group need to be linked together, this system allows stand-alone operation. Input options; allow signal traffic control, and customization to solve most signal collision problems.

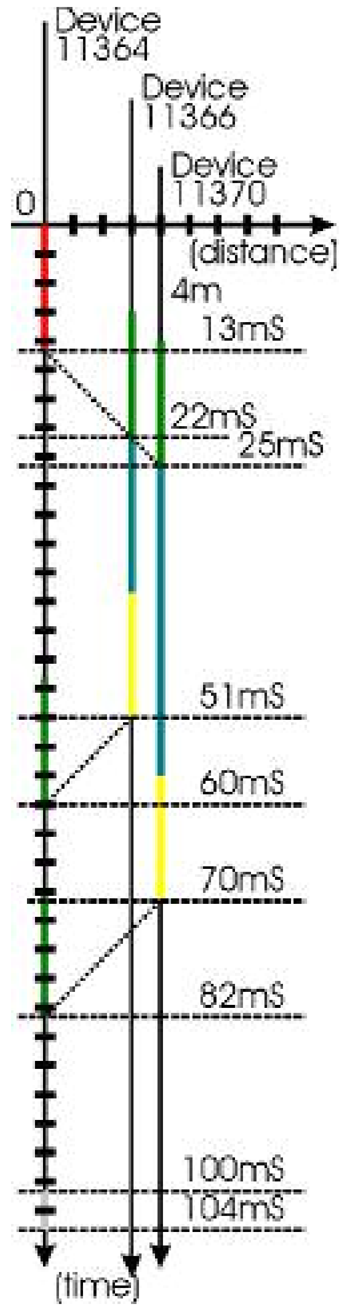
Caller-transceiver modes are limited to 16 callers and 63 transponders.

The HX11X Synchronous Differential Mode

Imagine that in the above; George, John and Jim are set up as receivers. And are linked to a computer, all of the receivers are synchronized by the computer. And then after a short period the computer receives signal logs from the receivers. Using differential signal analysis, the computer can determine the position of a tag or a transmitter. The XYZ program can sort the signals from a large number of receivers. And if it is provided with the position of the receivers, it can yield the 3d position of the transmitters and tags in relation to the receivers.

In Synchronous mode, there can be 1023 identity transmitters like Peter and 32340 listeners like George, John and Jim. So the network can be quite large, and extremely fast. Each tag can signal up to 36 times per second. The speed of the system depends largely on how fast the computer can run the XYZ program.

Ultrasonic Event Chart (Asynchronous)



The red line on the event chart represents signal transmitted by the caller. Green line, represent the caller signal received by the transponder, and the blue lines represent transponder delay. Yellow lines represent transponder-encoded reply. The gray line represents serial port transmission duration.

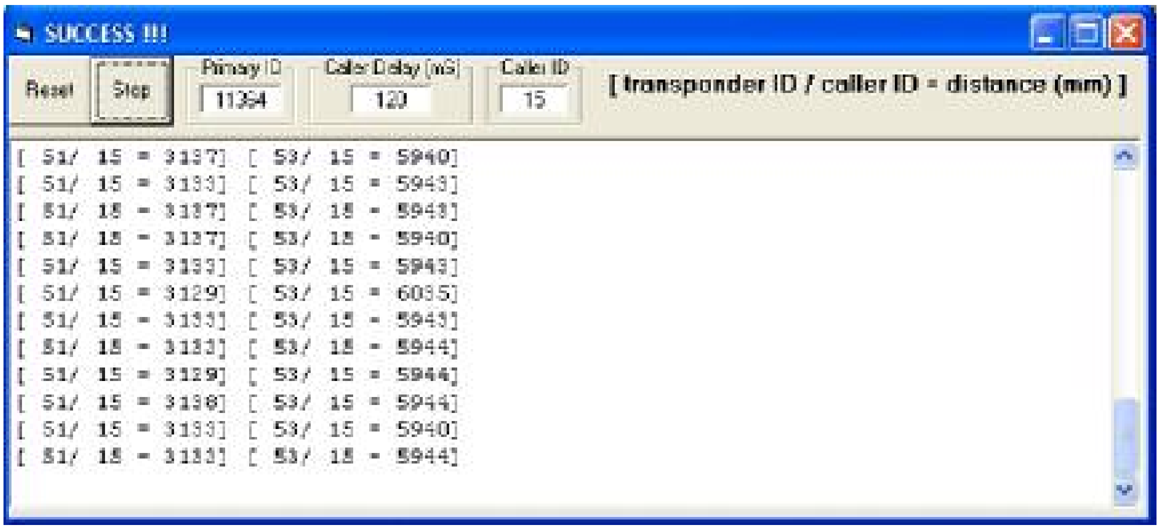
The encoded reply, by transponder 11366, to a caller with ID=1 will be an encoded combination of its own transponder ID, and the caller ID, or 331. Similarly the reply from transponder 11370 will be 351. The user controls the content of the call, and the user also determines, how many blue line delays are introduced onto the event lines. The user does this by setting the transpond delay. Device 11366 has its transpond delay set to 1, device 11370 has its transpond delay set to 2.

Device 11364 transmits its call at time 0; the signal has to travel for about 3m before reaching transponder (device 11366). Then it must travel, further 1m to reach device 11370. The travel adds time to the transaction. At 22mS device 11366 logs the time of the signal arrival into its ring buffers, and starts timing its response delay. Without synchronization, this particular timing has little meaning. At roughly 25mS, device 11370 logs the time of arrival of the signal from device 11364. At 51mS, device 11366 has encoded the signal from device 11364 and transmitted its response. At 60mS, device 11364 receives reply and logs time of arrival. By subtracting reply and signal delays, the time of signal flight can be calculated. At 70mS, the transponder device 11370 has encoded the signal from 11364 and transmitted its response. At 82mS device 11364 receives the transpondance from device 11370 it decodes the signal and stores the results and time of arrival in its ring buffers. At roughly 100mS device 11364 transmits it's ring buffer contents through the serial port, clears it's timers and repeats the cycle.

The event chart illustrates the sampling rate limitation for the operation. A two-device transaction between device 11364 and device 11366 over a distance of 3 meters, can't be much higher than 16 samples per second. By the same token a three-device transaction will take about 82mS (12 samples per second). As the distance is increased, time of travel decreases the sampling rate possible. In synchronous modes the sampling rates can be much higher since the signal travels only one way with less signal delays and no transpondance delay. Smart combination of synchronous differential modes and asynchronous modes can be used to acquire higher sampling rates.

Program Hx11unit.exe

This program reads data from devices set up as callers, it serves well for private connection between Hx11 devices and a readout devices able to run windows programs. **The source code is available on our website** to help system integrators understand how to calculate real distance from device to device. The Hx11x is only accurate to within about 9mm in full asynchronous mode. Higher accuracies can be achieved with statistical filtering.



The Reset button sends the parameters to the hx11 device specified in the Primary ID text window. After the parameters have been stored in permanent memory the device is re-booted. These parameters will be loaded into the device every time it is powered up. The Stop button stops the data stream from the hx11 device. If it is attempted to send the parameters using the Reset button while data is still streaming from the Hx11, the device might not receive the parameters.

Device with primary address 11364 was configured with a caller Delay of 120mS. This means every line in the display window below takes 120 milliseconds. The device was given the caller ID 15. Devices with transponder address 51 and 53 have responded to the call. The distance to device 51 is approximately 3134 millimeters, and the distance to device 53 is about 5942 millimeters. The primary address, transponder address and tag address is written on the label sticker of the hx11 device.

When configuring many callers in a tight system; keep in mind that callers with identical caller delays might end up sending signals at identical rate. If these signals collide (in terms of time, not in terms of space), they are damaged. The red line in the event chart above is 16mS. Set the caller delays at least 16mS apart to reduce chances of signals colliding repeatedly.

Limitation and Specification

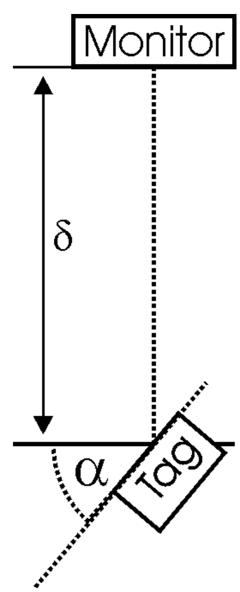
For a system of overhead transponders and mobile callers, only 16 unique callers can be distinguished by the transponders. It two callers with the same ID are located within range of the same transponders, the positioning for these two callers will be unreliable. Only 63 unique overhead transponders can be identified by the caller. Grouping transponders with same Ids differently depending on location can make a very large system of callers/transponders possible. Note that it is not absolutely necessary for transponders to be overhead and callers mobile, this is left to the user's imagination. But for an overhead system the transponders should be grouped between 1 and 1.5 meters apart.

For a system of overhead receivers (monitors) and mobile transmitters, 1007 unique transmitters (tags) can be tracked. Up to 32340 uniquely identifiable receivers can be set up, 1 to 2 meters apart per network, the network can therefore span a large area. If two tags with the same ID numbers are detected by the same overhead receivers, neither might be logged. Grouping in a smart way can help increase the size of the system. Again the setup should be subject to the user's imagination, receivers do not have to be overhead and transmitters don't have to be mobile.

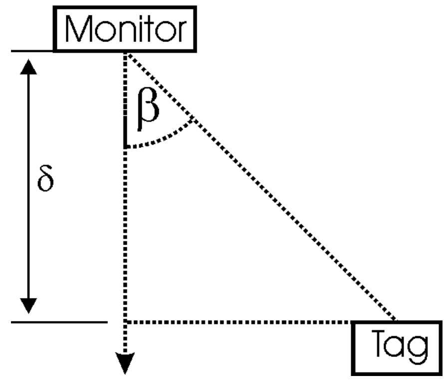
The probability of missed signals increases in direct proportions to the angle and the distance from the receiver. Distance, angle, shear and tunneling limitations are specified by 50% missed signals. I.e. at the limitation boundaries only half of the emitted signals are logged. All specifications are based on one-way travel of the signal, i.e. from transmitter to receiver. In the case of callers and transponders the signal must travel both ways for a complete operation this induces higher signal losses.

Rotational Angle

Tag rotational angle relative to a receiver is a function of distance δ from the receiver. The angle α at which monitor misses 50% of the signals is in inverse proportions to the distance from the receiver. I.e. the further away the tag is from the monitor, the smaller is the angle. The range is specified to a distance where α is no less than +/- 10 degrees.

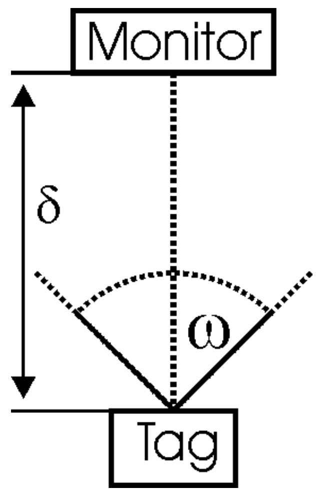


Shear Angles



A tag moving on axis parallel to the monitor sets up what we refer to as a shear angle β. This angle is a function of the distance δ. The distance δ is specified to a point where this angle is no less than +/- 10 degrees. Note that the angle β is in inverse proportions to the distance δ.

The Line of Sight

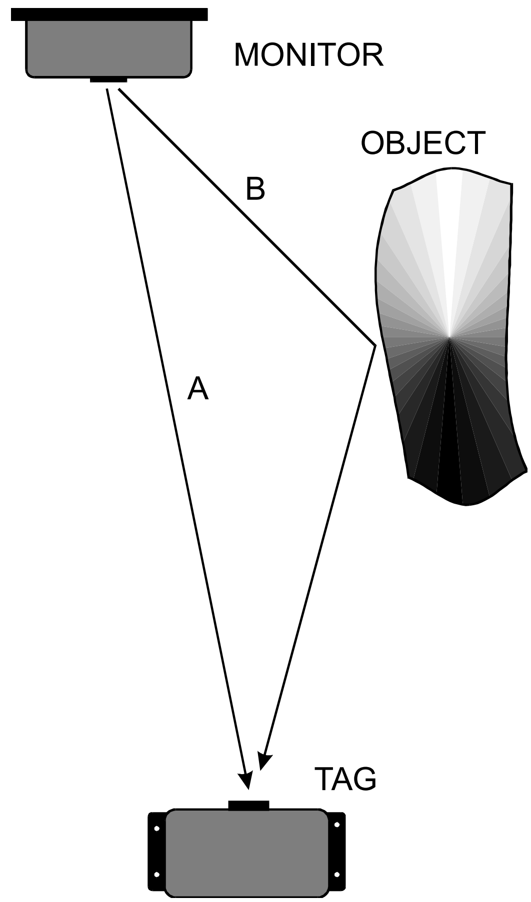


Like light, ultrasound can be blocked by objects. If the objects are small, large portion of the wave will go around the object and insignificant damage is done to the signal. But if the object has a large reflective surface, some damage may come to the signal even if the object is not directly blocking the signal. Walls and ceilings are such surfaces. The specifications given in this document are based on ω not less than +/-45 degrees clear line of sight, i.e. no object within these boundaries. In most cases but not all, overhead mounting ensures the best line of sight.

Signal collision or Overrun

If a HX11X monitor receives two signals less than 13 mS apart it will either not log one of these signals, or log neither. In other words it will miss one or both. Care must be taken to set the transponder delay and transmit delay to minimize collision.

Hostile Conditions



If the difference in distance B-A in figure A4 is less than 4.5 meters, signal read error might occur. The smaller the difference in distance the higher the probability of error. Errors with respect to a tag in relation to a monitor also become more likely with increased distance, angle and shear angles.

Overrun errors

Overrun errors occur when two tags in the vicinity of one another both transmit at the same time or nearly the same time. The probability of an overrun error is directly proportional to the number of tags exposed to a single monitor.

Overrun error probability

OEP = (0.013*N-0.013) / (A-0.013)

Where N is number of tags and A is the duration of the Tag Signaling Cycle.

Most errors are suppressed by the system, an error tag encounter is not saved. This depends on the quality of the error rejection function of the Hx5 system. Some errors will however penetrate the defenses and be counted. There are number of ways for the user to reject these errors.

If a tag ID is detected by one monitor only, and isn't detected many times in a row; this is certainly an error.
If there is a position jump between samples, this could be an error. Application of standard deviation procedures may help eliminate these errors.

HX11 Specification Asynchronous Mode

Positioning Timing Resolution Per Monitor	0.03 mm
Open Field Absolute accuracy over full range	11mm
Position Repeatability	11mm
Maximum Update Rate (Positions/Second/Monitor)	15
Maximum number of Monitors per Network	63

HX11 Specification Synchronous Differential Mode

Positioning Timing Resolution Per Monitor	0.03 mm
Open Field Absolute accuracy over full range	9mm
Position Repeatability	9mm
Maximum Update Rate (Positions/Second/Monitor)	36
Maximum number of Monitors per Network	32340

Position Resolution

This is the physical timing resolution; meaning if the position changes by 0.03mm a change in distance value should be noted. This resolution can be approached in a case of a slow moving object, where there is time for hefty statistics and data averaging.

Open Field Absolute Accuracy

Position is nowhere off by more than 9mm in synchronized modes over the full range. Given that the air medium remains the same in terms of speed of sound and no objects obscure the wave.

Position Repeatability

Given constant conditions of the air medium, if the transmitter is moved into a previously held position, the new reading will not deviate more than 0.1mm from the original reading on the average. This makes calibration for high absolute accuracy possible.

Maximum Update Rate

The maximum update rate is specified 36 samples per second. This is not achievable with the XYZ program. It needs two samples before it can yield 3D coordinates. Hence sampling rate here cannot be higher than 18 samples per second.

Monitors per Network

The maximum number of monitors per network is 32340. If there is one monitor for every square meter 32340m^2 can be covered with a single network and a single computer. If more coverage is needed more networks can be added.

Monitor Noise Immunity

The HX11 transmission is frequency modulated. To block or upset the transmission, a signal noise must exist in the 40khz +/- 1Khz band. If the volume of this signal is 5db lower than the HX11 transmission at the receiver, no distance distortion is measured. In other words the noise must overwhelm the transmission.

Software for reading (real time) and storing data

The HX11 system comes with a few programs designed to make 3 dimensional position data available in real time to the user, and log data as it becomes available. These programs need network connection to a group of at least four HX11X monitors. The medium size evaluation system is a minimum for synchronous differential mode.

Data.exe

This program reads data from the HX11C (network controller). It stores the data on a file name monData.hxm.

XYZ.EXE: Reads data from the HX11 network via the serial port, and converts the data to tag Id, 3D coordinates and time. It also converts the file collected by the hx11data program "monData.hxm" to tag ID, 3D position and time. This data is stored on a file named by the time and date the data was acquired. The user can tap into all data as it is being created by the xyz.exe program; for real time monitoring. This is done using DDE (Dynamic Data Exchange) see (DDE example) in the software section.

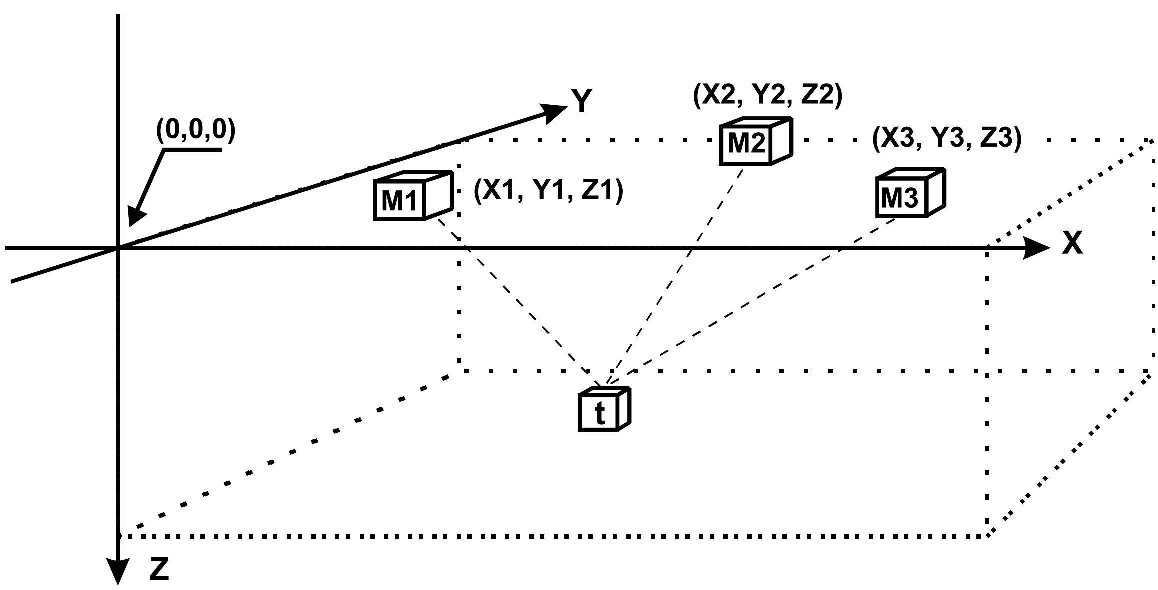
LAYOUT.EXE: allows the user to set up the positioning network (location of receivers/monitors) visually on a floor plan or a background picture (gif image). 3d positioning files created by the xyz program can be displayed on the image. The user can back step through the position timeline on the background image and replay any sequence. The positions of the tags can also be displayed in real time on the background image as the data it is being sampled.

The XYZ program

The xyz.exe and layout.exe come with a HX11 positioning system see (The basic system section)

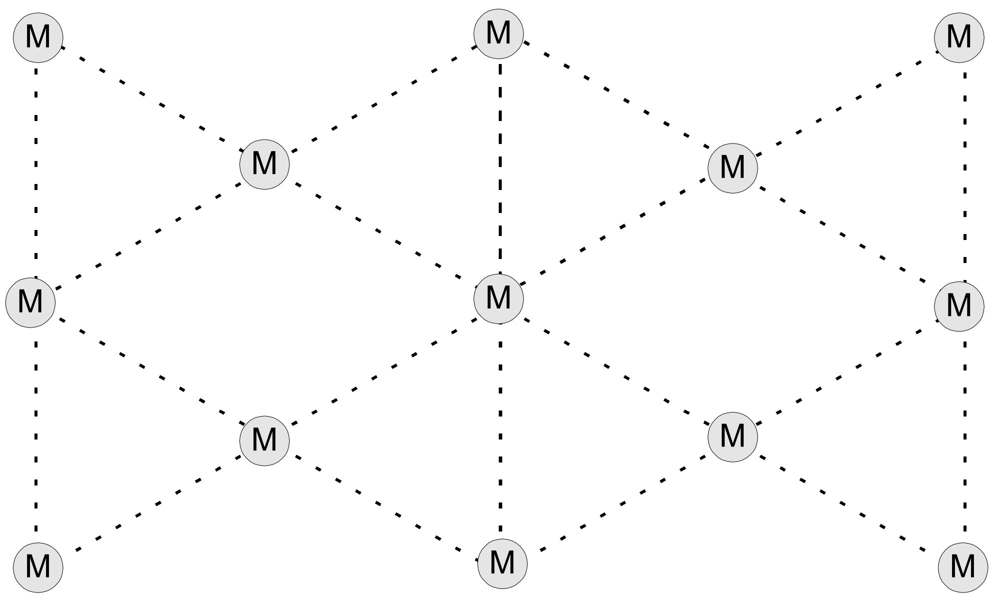
The XYZ program requires that the (x,y,z) coordinates be specified for each monitors on the network. These coordinates can be entered into a text file (layout.hxm) either manually or on a floor plan (background image) using the layout program. The xyz program reads this file and calculates the position of the tags based on these coordinates, relative to a single origin (0,0,0), placed at the users convenience. The tag coordinates and time of encounter are stored in directory [xyz Data]; on a file with a name given by time and data . Other program applications have access to the xyz data stream via DDE (dynamic data exchange).

An auxiliary program layout.exe helps set up the monitors visually. A floor plan or a picture in GIF format can be imported into the program as background. The program allows the picture to be scaled, and the user can zoom the picture in and out and move it around on the screen. The origin can be placed anywhere on the background picture and the monitors placed visually (graphically) according to measurement on the background. Layout.exe has features that allow the files created by the xyz program to be displayed on the background image. The positions of all the tags can be displayed on a timeline. I.e. these can be back stepped and forwarded at high and slow speeds and the positions of the tags can be frozen in time. The image below suggests how the monitors can be set up for example in a room where the 0 (xy) plane is the ceiling.



Wide Area Coverage

The illustration below suggests how a large area can be covered using monitors. Any formation can be chosen, but a honeycomb formation will provide one of the best coverage per unit cost. In the following the D distances between monitors are everywhere the same. The monitors form 60-degree triangles. Depending on the density of the network, many monitors may contribute to the positioning of a given tag. The higher then number of monitors that detect the tag, the more accurate and stable will be the positioning.



Setting up for Z evaluation

The HX11 operates on equidistance principle. It assumes there exist equidistance lines between the monitors (receivers) which all cross where the tag or transmitter is located. Imagine the receivers set up in a triangle, and the transmitter located at equal distance from them all. In this case equidistance exists along a line right through the triangle. Therefore the fourth receiver is needed to fix Z to a point rather than a line. If Z needs to be tracked, don't set the receivers all on the same plane.

Basic Components of the Positioning System

The HX11 uses only two types of devices for positioning. One device that can receive transmit, transpond and call. The letter after HX11 is always X for devices like this. The other type can only transmit and has the HX11 suffix T. A complete system can operate using only HX11X devices, optionally HX11T can be added to the system. The HX11T devices can be made small and energy efficient. For tracking systems using XYZ.exe the 3D triangulation software, the HX11C controller is needed.

The Basic System

The following lists the basics needed for the construction of a tracking or guidance system using the HX11 components

Hardware Needed for a Small Limited Speed Guidance/Tracking System

Transponders/Callers HX11X	Quantity depends on the area covered
Readout Device	Palmtop, Laptop, Desktop, Text Display
Regulated DC power supply	Minimum one supply per network

Software

HX11read.exe (see above), this is a visual basic code. The source code is provided for compilation on the machine of convenience.

Hardware Needed for a High Speed Large Tracking System

Receivers/Monitors HX11X	Quantity depends on the area covered
Transmitters/Tags HX11T	Quantity depends on the number objects tracked
Network Controller HX11C	One controller per network
Personal Computer	One PC per network
Regulated DC power supply	Minimum one supply per network

For a network containing more than 128 receivers, a HX11R repeater will be required.

If using a Network: Materials needed for network wiring

4 conductor telephone cable
FCC Modular Plugs 6/4 RJ11

The Transmitter

The transmitter transmits localization signal followed by its identification. HX11T is limited to 1007 unique identification. Hexamite can deliver custom systems with unique identifications in the millions.

The Power Supply

Voltage levels on the supply lines to the receivers should not be lower than 7 V and not higher than 16 Volts. In regards to the lower level, the voltage should never go below 7V dc, a microsecond spike beneath the level can disrupt the operation. Therefore regulated supplies should be favored.

The Personal Computer

The PC calculates the position of each transmitter based on the data from the HX11C. In the case of over 1000 transmitters being detected by several hundred receivers, a high speed PC should be used as a dedicated server. Most PCs will suffice for real time monitoring of a few transmitters and receivers. The communication and PC processing speed may become a bottleneck for large high-speed system. It may be necessary to split such network into smaller units each controlled with separate linked computers.

Controlling The System Update Rate

It takes each tag 13mS to transmit it’s identification and localization signal. The monitor needs 10mS to analyze and store signal data. Two random mode tags in range of one another updating at high speeds; will have high tendencies to overrun. The tag closest to the sensor is likely to override the tag further away.

The Small Evaluation System

The small evaluation system consists of four HX11X devices and one direct cable to RS232. With these configured as callers and transponders, they can be set up for 3D tracking and guidance of one point. Or they can be set up for 2D tracking and guidance of two points. And similarly three points can be tracked and guided on a single dimensional line. HX11read.exe program running on windows XP can be used to store the distances on a file and display the distances. Distances can also be accessed via DDE (Direct Data Exchange) interface. The source code for HX11unit.exe is available on line, to help the user write custom code for basic system integration. Additional HX11T units are (see table below).

Medium Evaluation System

The medium evaluations system consists of six HX11X devices one HX11C controller and one direct cable to RS232. Minimum four HX11X devices configured as receivers are needed to triangulate 3D coordinates. This leaves two HX11X devices free to be configured either as transmitters or additional receivers. The XYZ.exe given the minimum four devices will have enough information to triangulate 3D coordinates. Additional HX11T units are (see table below).

The Large Evaluation System

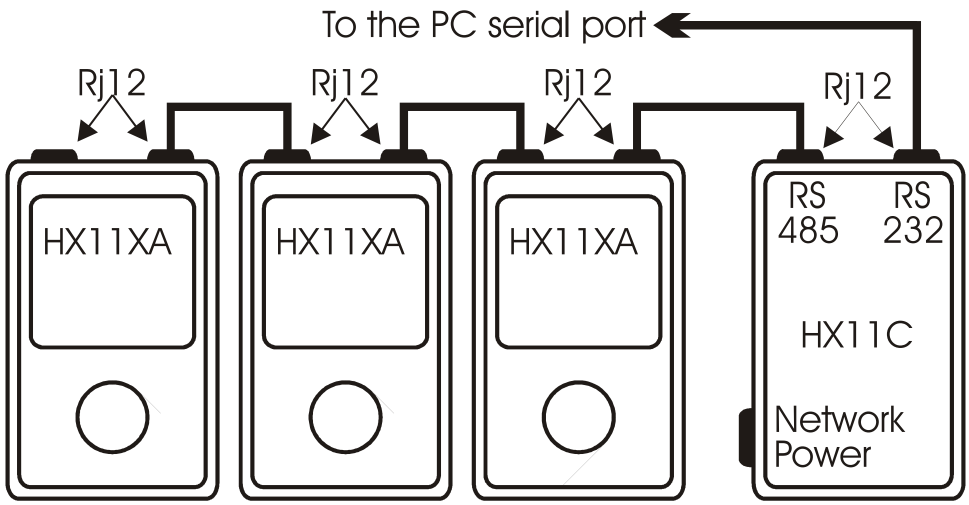
The large evaluation system consists of 48 HX11X units, one controller HX11C and one direct cable to RS232. It comes with system developer’s manual, containing concept explanation, operation flowcharts and detailed description of the HX11X. Visual Basic program source codes for: HX11data, XYZ, Hx11read, Hx11configure and layout is also provided. Additional HX11T units (see table below).

Documentation for System Integrators

It contains software for controlling the HX11X via serial port and Visual Basic Software Source Codes for all programs. It contains event charts illustrating signal interaction in air, block diagrams illustrating the basic operation of the HX11X and etc.

Hx11 network

The HX11 components can be connected to a network of devices utilizing FCC RJ11 style port. The RJ12 or RJ11 socket can be found on most domestic telephones, it is the socket which connects the telephone to the wall fixture. HX11 components have one or two RJ11 sockets. The communications and power to the HX11 is supplied on the network through the RJ12 port. It is eventually up to the user to use local, mobile or network power. Hx11 components have RS485 transceivers used for large networks, of several thousand hx11 devices communicating over long distance covering tens of kilometers.



The overall or total cable length should not exceed 10 miles or 16 kilometers for the RS485 network. All receivers have a direction diode on the input, reverse polarization does not harm the units.

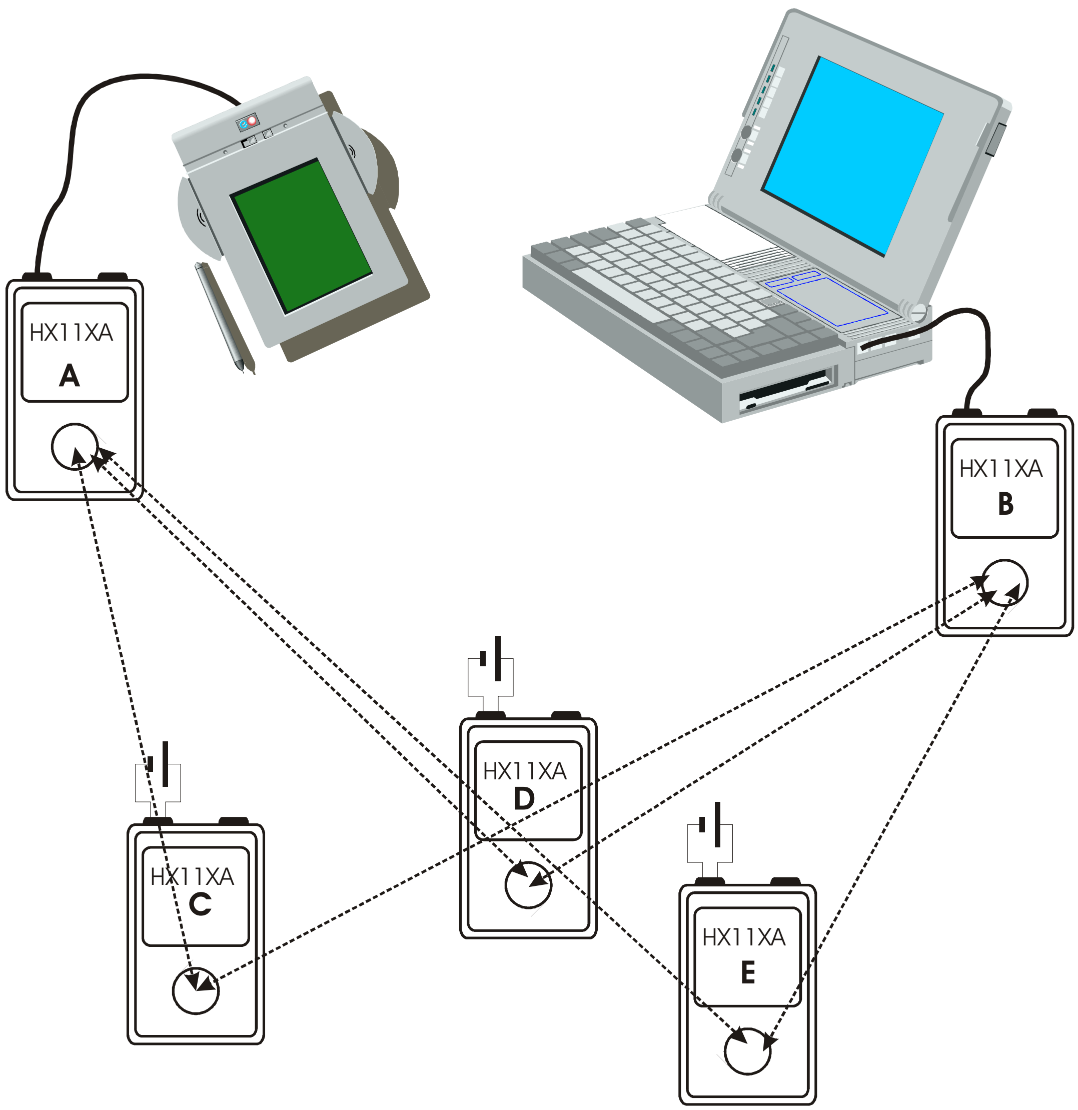
The Network Controller HX11C

HX11C controls the network and the communications with the PC, it should be located within 2 meters of the PC. The program xyz.exe reads the data from the HX11C and calculates the position of the transmitters detected. The power points on the HX11C are connected to the network power lines, and can serve to supply power to the whole network. Be aware that telephone lines carry limited amperes and there is a voltage drop in direct proportions to the wire length. In case of long lines, and high number of receivers it may be necessary to use local power for a far away cluster of receivers.

Note that it may be necessary to ground the power supply used to supply the network with power. Some switching power supplies used for laptops can cause excessive line noise.

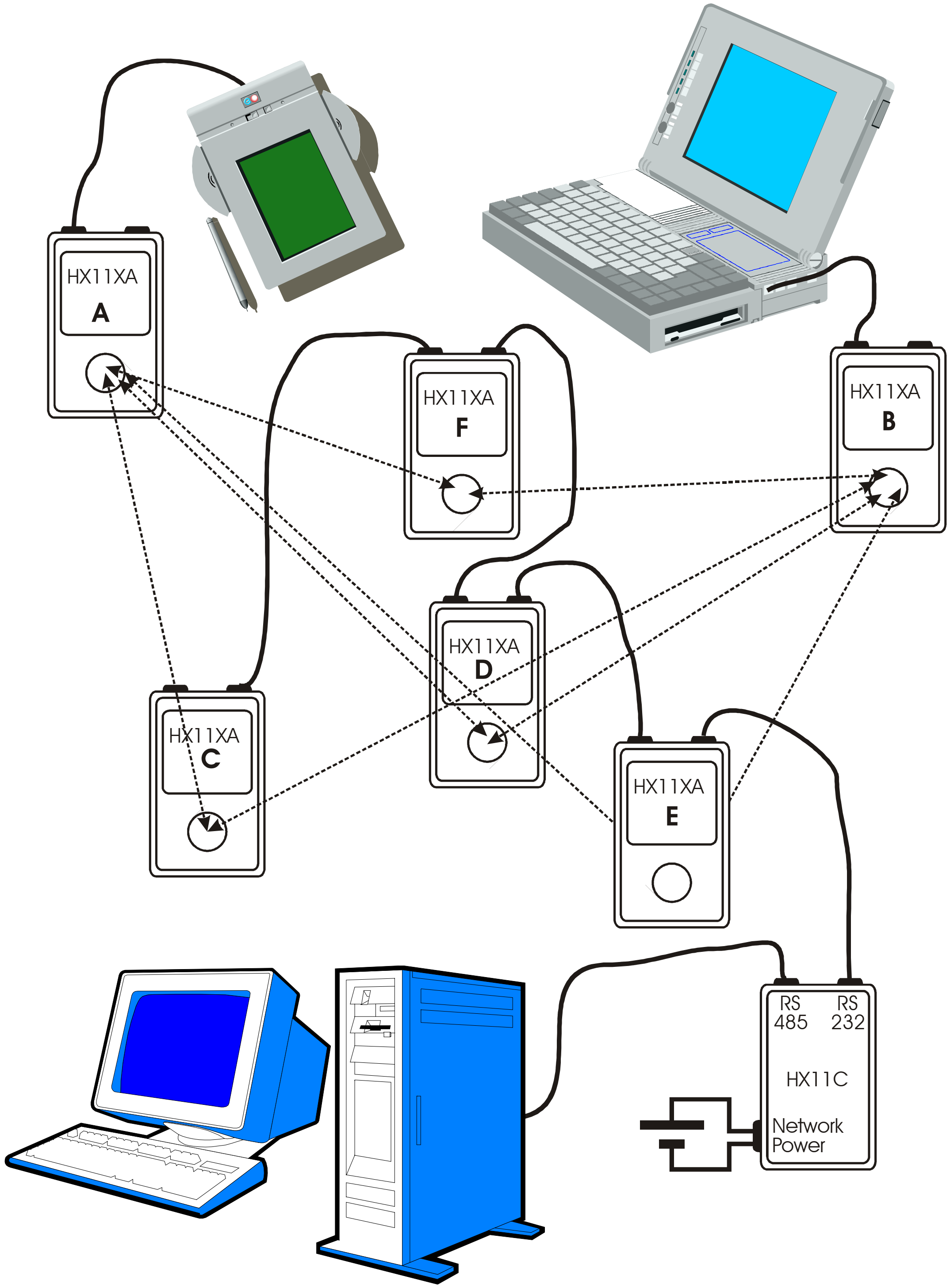
System Application example 1

Each HX11 device can be connected privately and directly to a serial port of a Microcontroller, PC, palmtop or a PDA as shown below. The PDA knows the distances A to C, A to D and A to E. Knowing the fixed positions of C, D and E the PDA can calculate it's 3D position. Similarly the laptop will possess the distances B to C, B to D and B to E for the triangulation of it's 3D position.



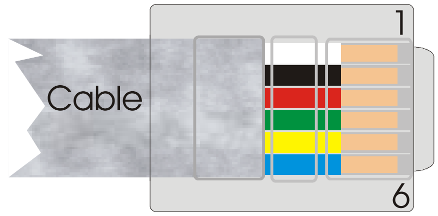
System Application example 2

If one more transponder F was added to the System Application Example 1 and a Network controller, then programs like xyz could be used by the desktop to triangulate the positions of A and B. Every 3D position is known to each device within a small fraction of a second.



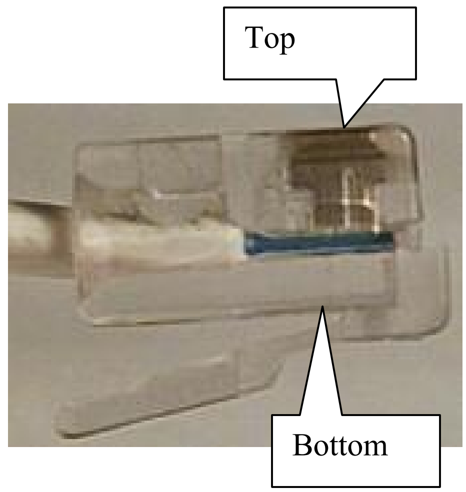
Communications Network Wiring

The images to the right show a RJ12 jack and what we mean by top and bottom. It also shows how the colors are situated. The colors in the illustration to the right are listed 1 thru 6 looking from the top into the plug. This equals looking into the RJ12 socket, where the leftmost pin is pin 1 and the rightmost pin is pin 6.



Local Power

Long line network may not be suited to carry the power to devices far away. Sometimes local power must be used. In this case the outmost RJ12 wires black and yellow should not be connected. For RS485 communication only the four innermost wires are used therefore Rj11 jacks are suitable.

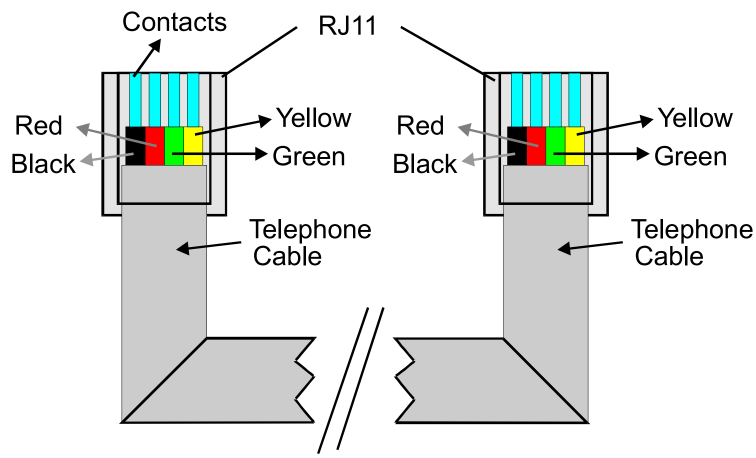


Long Line Considerations

If the network becomes kilometers long, a twisted pair should be used to carry the communications signal. The hexamite devices should receive power locally. Hexamite devices are not optically isolated, and some optical isolation may be needed. When common ground is used, keep in mind that the common mode voltage for the hexamite devices is +/- 7V.

Wire Configuration HX11 devices using RJ12			
Contact	**Wire color**	**Wire function**	Electrical Specs
1	White	Parameter Recovery	0 - 7 Vdc *
2	Black	Ground / Return (Negative)	8-16Vdc
3	Red	RS485 Positive **	+/- 7V
4	Green	RS485 Negative **	+/- 7V
5	Yellow	Power Input (Positive)	0V
6	Blue	Device Hard Reset	0 – 7 Vdc *
** Current forced through the Mode and Reset pins should never exceed 20mA*			
*** To connect the HX11 to a RS232 port on a computer, a RS485 to RS232 or direct cable is required. RS485 is suited for long distance communication.*			

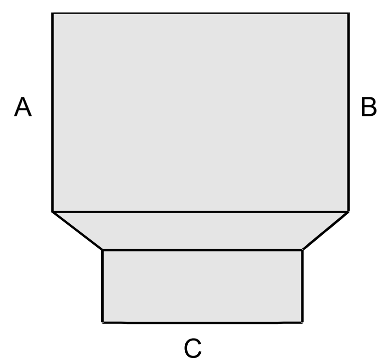
FCC RJ11 and telephone cables



The figure on the right shows how the rj11 needs to be attached to the cable. It is important that the colors match when looking down on both top sides of the cable end RJ11 plugs. **The cable connections should not be crossed.** Inexpensive tools are available to help join the RJ11 to the telephone cable. It does not damage the monitors if they are connected via inverted cable. But it could block out the network until removed and corrected.

Using T connectors

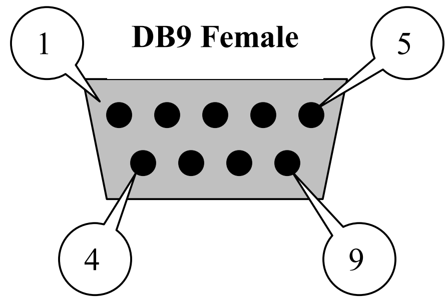
T-Connectors are generally available at hardware stores selling telephone cables and accessories. The T connector joins 3 separate telephone cables, and it has 3 RJ11 or RJ12 sockets A, B and C. **The Hexamite network should have no wires crossed.** Some T connectors have the C input inverted. In this case the cable connected via the C input must be inverted too.



On the network, pins 1 and 6 have no real use. And if the voltage limit on these wires are breached the device may be damaged. Therefore we recommend that you use RJ11 plugs and 4 wire telephone cable to connect the devices together. This way you reduce your chances of accidentally damaging a device. RJ12 and 4 wire telephone cable is also an option here.

Connecting the Network Controller to a Computer

The network controllers always come with a cable to connect to a computer. Sometimes the user needs longer or more cables. Following is information how to wire the network controller to a computer.



RS232 ports on most computers are 9 pin (DB9) male type connectors. The female type shown on the right (see sketch), needs to be connected to the FCC RJ12 or RJ11 plug for the network controller HX11C. See the following table.

Pins on D-Subs 9 or 25 pins are always marked with the appropriate numbers for the pins as shown above.

RJ12 Controller RS232 Socket	DB9 (pins)	DB25 (older computers)
2 (5V dc)	Not Connected	Not Connected
3 (Tx) (red)	2 (Rx)	3 (Rx)
4 (Rx) (green)	3 (Tx)	2 (Tx)
5 (Ground) (black)	5 (Ground)	7 (Ground)

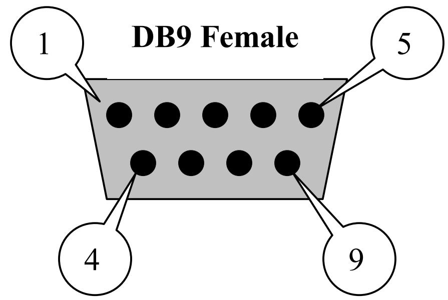
RS232 to USB

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.

Communications Private Connection

Connecting the HX11X to a RS232 PC, palmtop and etc.

When set up as caller the Hx11x sends identification and position data streams through it's RS485 pins. These pins can be connected directly to the RS232 port of a computer. **Note that the RS232 port receive and transmit pins should be connected together.** For a private connection to a computer or a Microcontroller consult the following tables.



Hx11x RJ12 Network socket	DB9 (pins)	DB25 (older computers)
2 (Ground / return)	5 (Ground)	7 (Ground)
3 Pos RS485 Not Connected	Not Connected	Not Connected
4 Neg RS485	3 (Tx) and 2 (RX)	2 (Tx) and 3 (Rx)
5 Positive Supply 8-16Vdc	Not Connected	Not Connected

Connecting the HX11X to a Microcontroller

The HX11X serial protocol is simplex, both transmitted data and received data are conducted through the same line or pin. If you are only receiving data from the Hx11 devices then connect the serial receive pin on your Microcontroller to the Pos RS485 i/o or RJ12 network socket pin 3. If you intend to dynamically configure the HX11 device, your serial transmit pin should be connected to the serial receive pin. *And when the Microcontroller is not transmitting data, the transmit pin should be in high impedance state.*

Hx11x RJ12 Network socket	Microcontroller
2 (Ground / return)	(Ground)
3 Pos RS485	Rx and (TX)
4 Pos RS485 Not Connected	Not Connected
5 Positive Supply 8-16Vdc	

Baud rates and settings

The Hx11 has two communication speeds, 250000 and 19200 baud. The user can switch between these speeds by setting bit number 6 of the Program Controller Byte. The HX11config.exe refers to this byte as CtlByte. If bit 6 of this byte is set when the HX11 is restarted the device will communicate at a rate of 250000 baud.

We have found that it is difficult to get devices and drivers for the PC to communicate at this rate. Therefore the Hx11 network controller has been set to communicate with the PC RS232 at 256000 baud, and the RS485 network at 250000 baud.

256000 baud is the fastest rate for VB Microsoft Serial Drivers. Not all RS232 hardware adaptors can handle this speed. Be careful to select capable hardware adaptors for the computer if high speed is required.

If the sixth bit of CtlByte has been set and the high speed hardware and software drivers are unable to communicate. The leftmost pin in the RJ12 socket must be grounded at the moment the HX11X is restarted. In this case default parameters are loaded into the work registers with the CtlByte equal to 0. Therefore the baud is back to 19200 and the hx11config software or the hx11unit software can be used to rewrite the EEPROM.

The communication parameters for the HX11X Positioning Devices are:

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

Operation.

On startup the device copies the setup parameters from EEPROM permanent memory into its work registers (temporary registers). Before the parameters are loaded into the work registers the program does a checksum evaluation of the parameters. If the checksum indicates the parameters may be flawed, it loads its default parameters into the work registers. It flushes the ring buffer (positioning data storage), and enters monitoring mode. In this mode it logs the time of arrival of valid ultrasonic signals. If the device has been synchronized the time of arrival is relative to last synchronization. Otherwise if asynchronous the time is relative to last overflow of the timer. The time appended to the identification code of the signal and stored in the HX11X ring buffer. If the identification code of the arriving signal is less than sixteen then the HX11X will transpond to that call signal. It does this by mixing the value of the received ID with it's own identification (remember GeorgePeter) code, and transmitting back that mixture. The mixture is transmitted back after user specified delays. The delays should be selected to minimize 13mS frame conflict.

Coverage and system size

The number of receivers required for an area can be roughly estimated using the following relationship:

Let distance between receivers = δ

Number of Receivers = $((\text{Area Covered})^{1/2}/\delta)^2$

Example:

Given that $\delta = 1.5$ *m*
Area Covered = $100\ m^2$

Then

Number of Receivers = $((100)^{1/2}/1.5)^2 = 44$

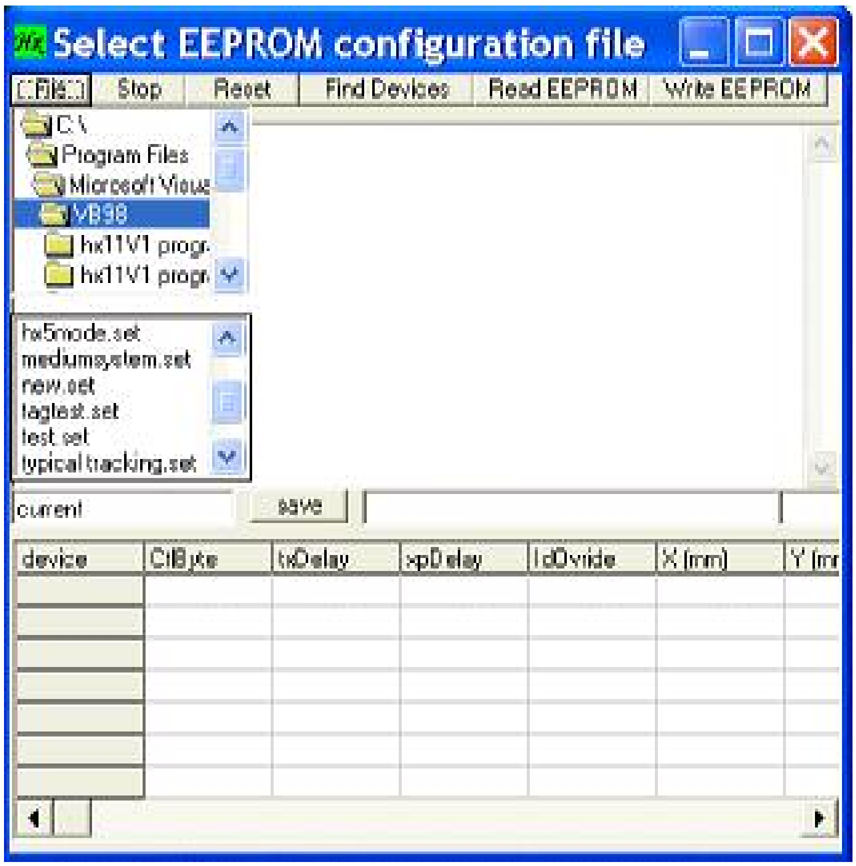
Unpacking and Starting the HX11T

The HX11T is shipped switched off to conserve battery power. Remove the plastic switch cover taped to the unit and press the switch down gently. Hold the switch down until you observe a flash on the LED. Each time there is a flash on the LED, the unit transmits identification and positioning signal. If the switch is held down the frequency of the flashing will increase until the unit becomes switched off.

EEPROM configuration

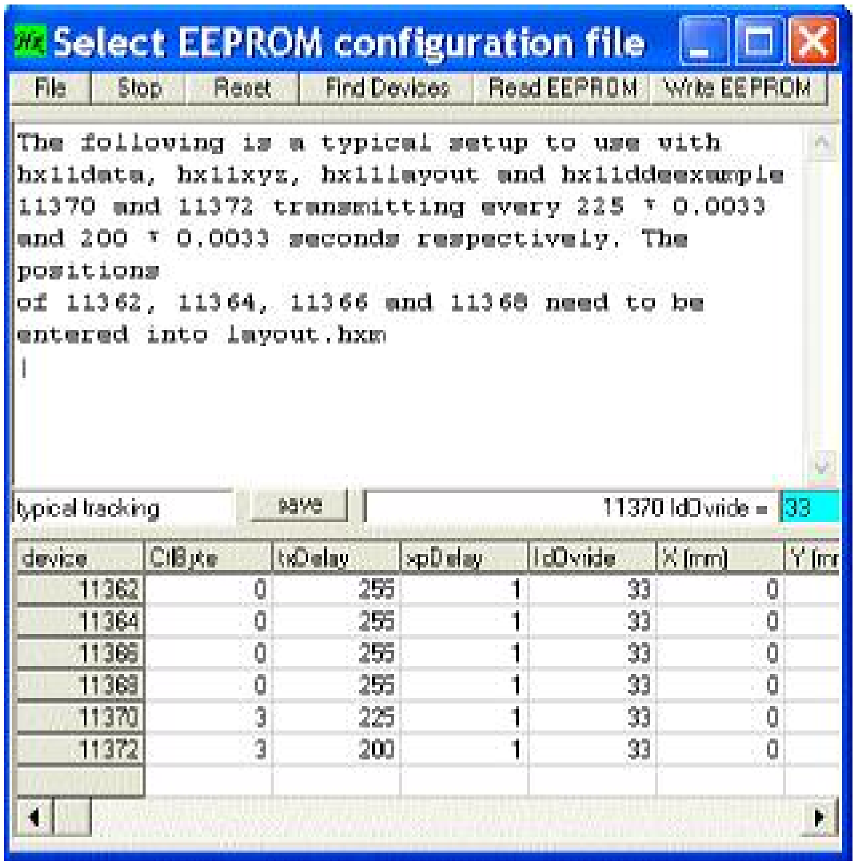
The hx11unit program can be used to configure EEPROM for a small system setup. The user will have to set up each device one by one. The Hx11config allows configuration of all devices on the network.

The Hx11config helps configure the EEPROM of the hx11 devices. Use the file option to select the *.set file. To read the EEPROM contents of all the devices on the network, then click "Find Devices". It can take up to 120 seconds to log all the devices on the network. Once all the devices are listed, there is no need to wait further. The addresses of the listed devices are displayed in the Device column of the table below the text window.



Once the device addresses are available, click on "Read EEEPROM" and the contents of those devices listed will be displayed in the table. The user can change the setup values and then click "Write EEPROM" to upload the EEPROMs of the devices listed.

Alternatively, files with preset configurations can be uploaded into the Hx11 devices available on the network. Click on the "File" button and select the configuration file. The user can create and configure own setup files. These files are text files and can be viewed and edited using normal text editors. Remember to put the Or sign "|" after your comments. The program hx11config can also be used to manipulate the *.set files. Click on the grid that needs to be changed, and change the value in the colored box.



The typical tracking example shows devices 11362, 11364, 11366 and 11368 configured as receivers/transponders. Devices 11370 and 11372 are configured as callers. Note that all the devices have IdOverride set above 15. Therefore no transponder will transpond to the calls of the devices. This column is irrelevant for devices set up as receivers, but relevant to devices set up as transmitters or callers. Since IdOverride is greater than 15 11370 will be transmitting their tag Id's rather than their caller Id's.

They above is a typical tracking setup for a medium evaluation system. The table also allows the user to enter in the coordinates for the receiver. No need to setup coordinates for the tags, not necessarily but typically they are moving. It is possible reverse the situation where the tags are stationary and the receivers are moving.

Once the table is correct for the given situation, click “Write EEPROM” to upload the parameters. You may need to click on “Reset” to startup all the devices and load the parameters into the work registers to start operation.

The text window, is used to display the network data stream. To stop the operation click “Stop” this action clears the CtlByte, and to resume operation click “Reset”.