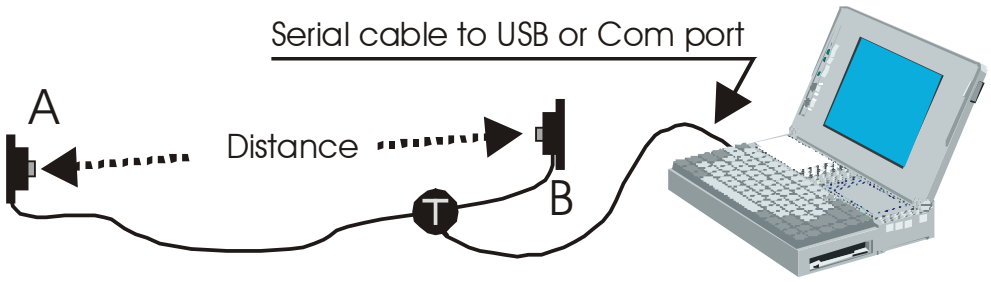
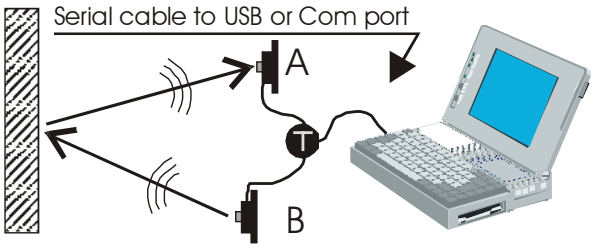
Wired high speed ultrasonic point to point distance measurement



The image above illustrates a synchronous ultrasonic distance measurement, a situation where it is possible to connect A and B together via cable. Using cable provides the fastest positioning application of rates over 15 samples per second. Readily available T connector allows a computer with a serial port to control the operation.

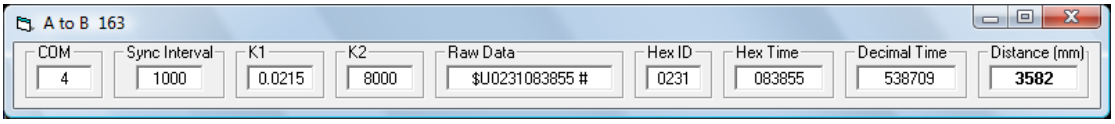


The illustration to the right shows the same system used for echolocation. This is a very robust operation, since the Hx11 is signal selective, the echo must have a given form to register the distance. I.e. environment noise has little effect on the measurement. Again the advantage here is speed. The system doesn't have to wait for a signal to bounce back, nor does it have to wait until all echoes from the previous signal have decayed sufficiently. Note that the devices don't operate on single wave first echo bases, so instead of registering shortest distance to the object, it registers the average distance.

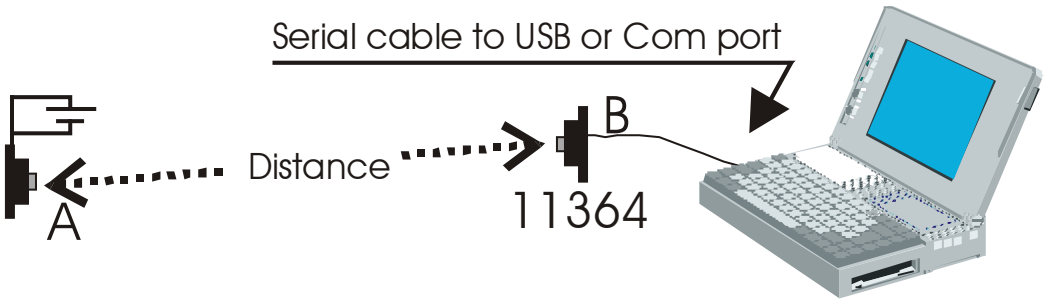
Use the configuration utility hx11config.exe to configure the devices on line for the application above.

FILE: Distance A to B.set (See software utility)

```
This is a point to point example where both devices are wired to
the serial port, send $x where x (dummy) is any character. The
start bit of the dummy character x synchronizes all devices on
line. Device 11362 will transmit a signal at the end of (txDelay
11). Device 11364 (mode=2) will measure the time of flight and
output the proportional distance to device 11362 at the end of
(txDelay 128).
|
11362          1              11           1              33
11364          2             128           1              33
```

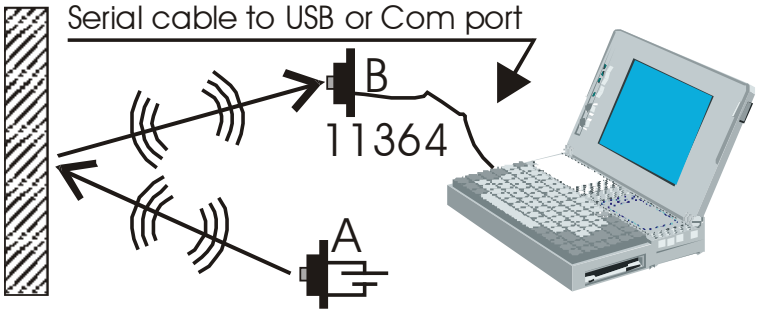


Wireless ultrasonic point to point distance measurement



The image above illustrates a wireless point to point example, this is an asynchronous ultrasonic measurement. Device 11364 is configured as a caller that measures the time it takes A to bounce its signal back. (see the configuration utility).

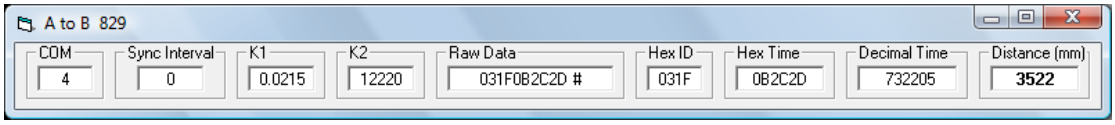
The illustration to the right, shows how the signal can be reflected of an object. If the surface is fairly flat, the signals should survive the two-way reflection.



Use the configuration utility hx11config.exe to configure the devices on line for the application above.

FILE: Distance A to B wireless.set (See software utility)

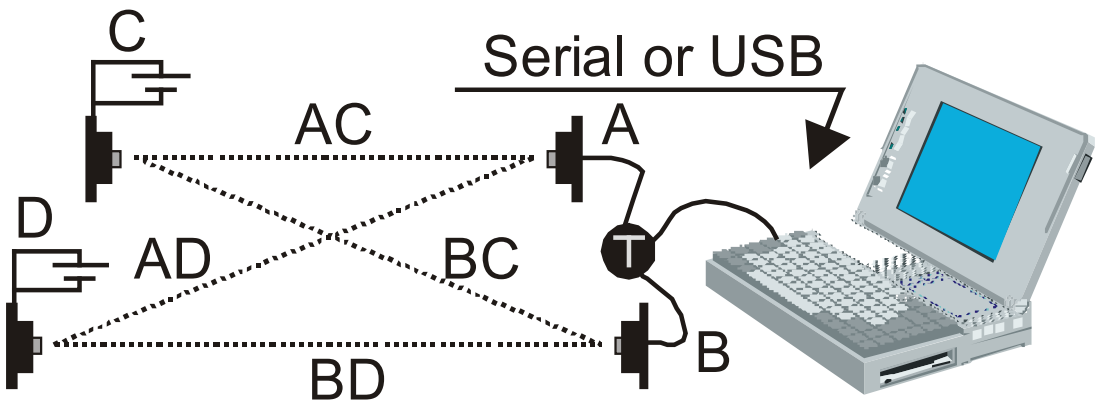
```
This is a point to point example where A and B are not wired
together. Device 11362 transponds to 11364 call.
|
11362          0              80             1              33
11364          7              255            1              15
```



Ultrasonic positioning of multiple objects from more than one perspective.

In the illustration below, A and B are shown connected. They do not have to be connected, but there is an advantage linking them together, signal collisions are avoided. Signal collisions occur when two devices within range of each other signal at a similar time. In other words devices signaling within time and space range can collide. If it is possible to live with occasional missing signals then of course there is no problem. There should no less than 10 mS from the end of one signal to the start of the next, and signals are 15mS long.

It is therefore an advantage to reduce asynchronization as much as possible, and in the example above A and B are connected together, this way signal triggering can be controlled.



The image above suggests a setup where two free moving objects D and C are positioned with respect to points A and B. Given that devices A, B, C and D have the device addresses 11362, 11364, 11366 and 11368, then:

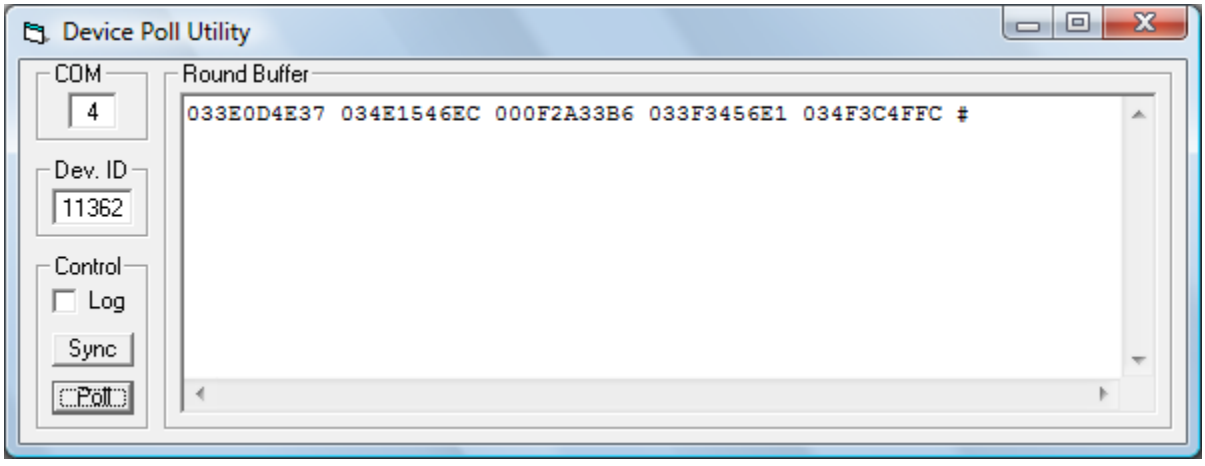
The following file contains the configuration parameters for application above

Positioning multiple objects from more than one perspective.

```
|
11362          5              1              1              14
11364          5             40              1              15
11366          0            255              1              33
11368          0            255              3              33
```

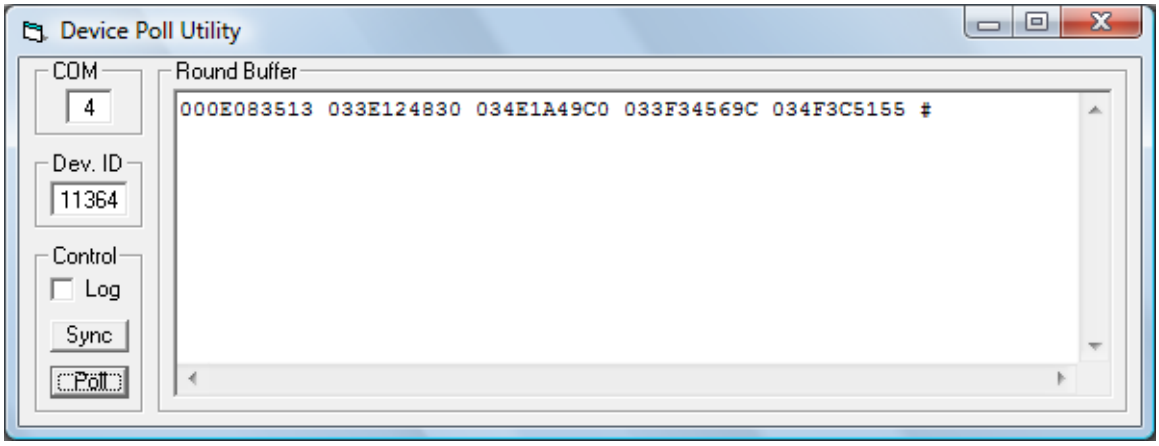
Hx11 Identity table (see device front face label)		
Device Id	**Transmitter ID (hex)**	**Transponder ID (hex)**
11362	231	31
11364	232	32
11366	233	33
11368	234	34

The four Hx11 units in the illustration above were placed face up on a table, and the signals bounced of a ceiling roughly 2 meters away. The signal had to travel from the caller to the ceiling 2m, back from the ceiling to the transponder (another 2m), and then the same way back from transponder to caller. The devicePoll program was used to generate synchronization, and poll the devices for the contents of the ring buffers. The interval between synchronization and polling naturally has to be longer than the travel time of the ultrasonic signal.

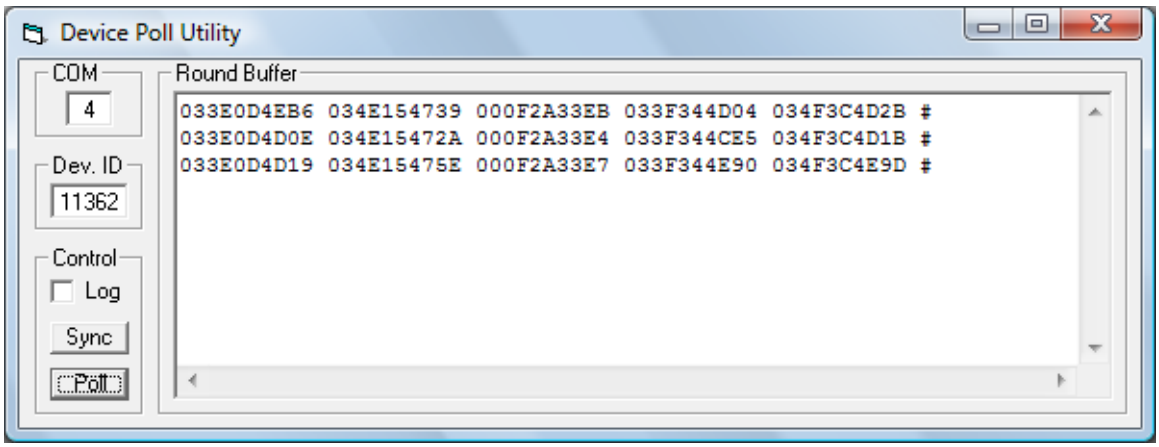


The device polled 11362 is caller 14 or E (hex), the first value 033E0D4E37 is the transponse to its own call from device 11366 (see identity table). The second value is the transponse from device 11368. Value number three 000F2A33B6 contains the time when the call from device 11364 (caller F see identity table) arrived. Device 11362 does not store the echo from its own call. The fourth value 033F3456E1 is the transponse by device 11366 (transponder 33) to the call of 11364 (id F). And the last value is the transponse to call 11364 (id F) by device 11368 (transponder 34).

Using the same setup the ring buffers of device 11364 can also be inspected. The first signal is the call from device 11362 (caller E). This is followed by the response to the call by transponders 33 and 34 (see table). And finally there is the response to its own call (Id F) by transponders 33 and 34.



The following is an example how polling can be repeated (click sync and poll many times); the signals are bounced of the ceiling i.e. secondary positioning, note that the least significant number is 62.5 nS or 21.5 nano meters.



To re-examine the setup parameters with respect to time delays, it can be seen that txDelay has been set 1 for device 11362. This means the device will fire its call approx. 4mS after the device receives Sync. Device 11364 fires its call approx 160 mS after receiving sync. Device 11366 responds to incoming call 16.384 mS after receiving the call, while device 11368 responds to an incoming call 3x16.384 or 49.152 mS after receiving it.

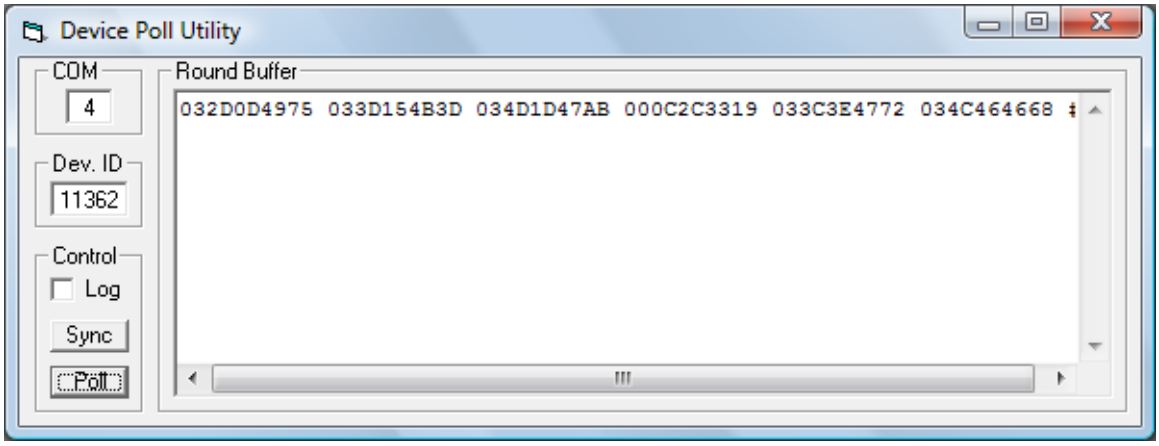
Positioning multiple objects from more than one perspective.

|
|---|---|---|---|---|
| 11362 | 5 | 1 | 1 | 14 |
| 11364 | 5 | 40 | 1 | 15 |
| 11366 | 0 | 255 | 1 | 33 |
| 11368 | 0 | 255 | 3 | 33 |

To better understand the Hx11 the configuration parameters are changed to the following.

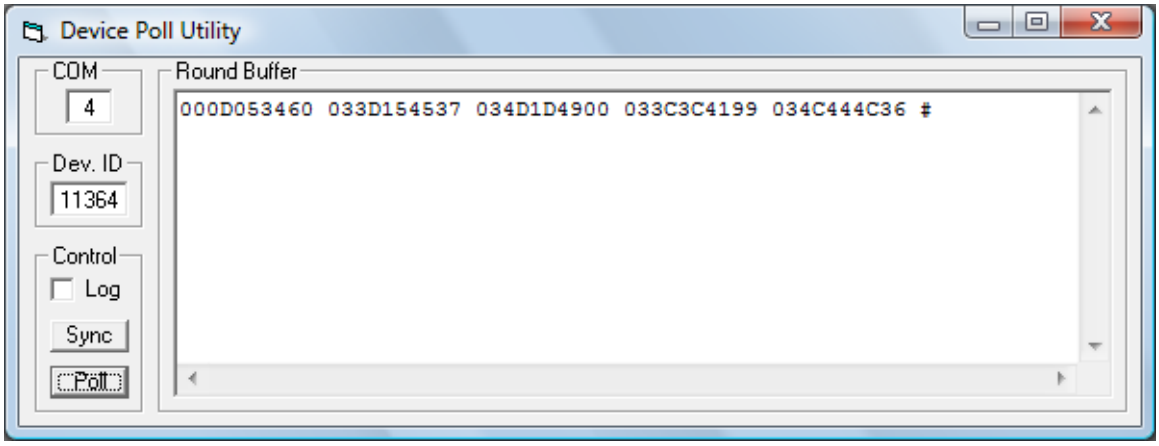
Positioning multiple objects from more than one perspective.

|
|---|---|---|---|---|
| 11362 | 5 | 1 | 1 | 13 |
| 11364 | 1 | 40 | 1 | 12 |
| 11366 | 0 | 255 | 3 | 33 |
| 11368 | 0 | 255 | 5 | 33 |



What has happened here is that now device 11364 is both a caller and a transponder. First three signals are response to call 13 (hex D), Transponders 32, 33 and 34 all respond to call (D). Following these signals 11362 first detects the call of device 11364 (id C). Be aware that transponder 32 (11364) does not transpond to its own call, so only transponder 33 and 34 transpond to the call of 11364.

The content of device 11364 can also be examined and as can be seen below, it detects the call of device 11362 (caller D), and it also detects the transponse of transponders 33 and 34.



The final two numbers are the response of device 11366 (transponder 33) and transponder 34 to its own call, i.e. call C.

Note: All devices have signaling overheads and should be individually calibrated.

All of the values are stable to within about a wavelength roughly 8mm, and all of these values can be calibrated to reflect the true distance. By averaging a few distances, a fairly accurate distance measurement can be achieved. This is especially true for wired application with one transmitter and many receivers to evaluate the distance.

Guidance, tracking, orientation and moving frames

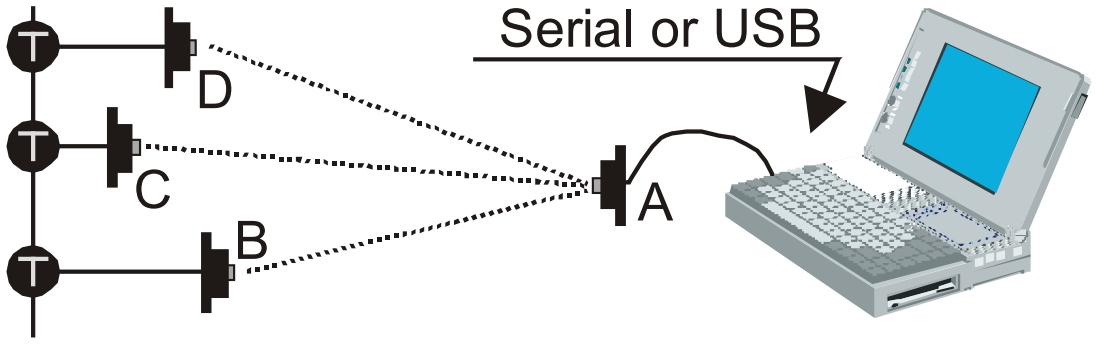
Network Systems and Ultrasonic Positioning.

The tracking application is well covered with the HX11 system. Software written for this purpose comes with the system. It needs to be pointed out that the HX11 can be configured for Guidance as well, and it can be configured for any combination of tracking and guidance.

Tracking is about you knowing the whereabouts of someone else, while guidance means you know your own position in reference to something else. In terms for the system, tracking defines the acquisition of mobile ultrasonic transmitter positions with respect to a frame of reference or receivers in known positions. While guidance, defines the position of the mobile ultrasonic receivers, with respect to the known positions of ultrasonic transmitters or transmitter frames. Sometimes a combination of both guidance and tracking may be needed, i.e multiple moving frames. The HX11 can be configured to do both tracking and guidance, and it can do so simultaneously, without any radio or wire link between the position reference and the observer.

Typical Ultrasonic Guidance Network

The illustration below shows devices B, C and D connected together using T connectors (available from most hardware stores). Here the transmissions of B, C and D occur at know interval from synchronization (txDelay x 4.096uS). This delay must be subtracted from the time-tags after they are stored in the ring buffers of A. Then the time deviation can be determined by subtracting the times of arrival from each other. 3D triangulation or use of intercepting circles can be used to extract the position of A with respect to the network frame.



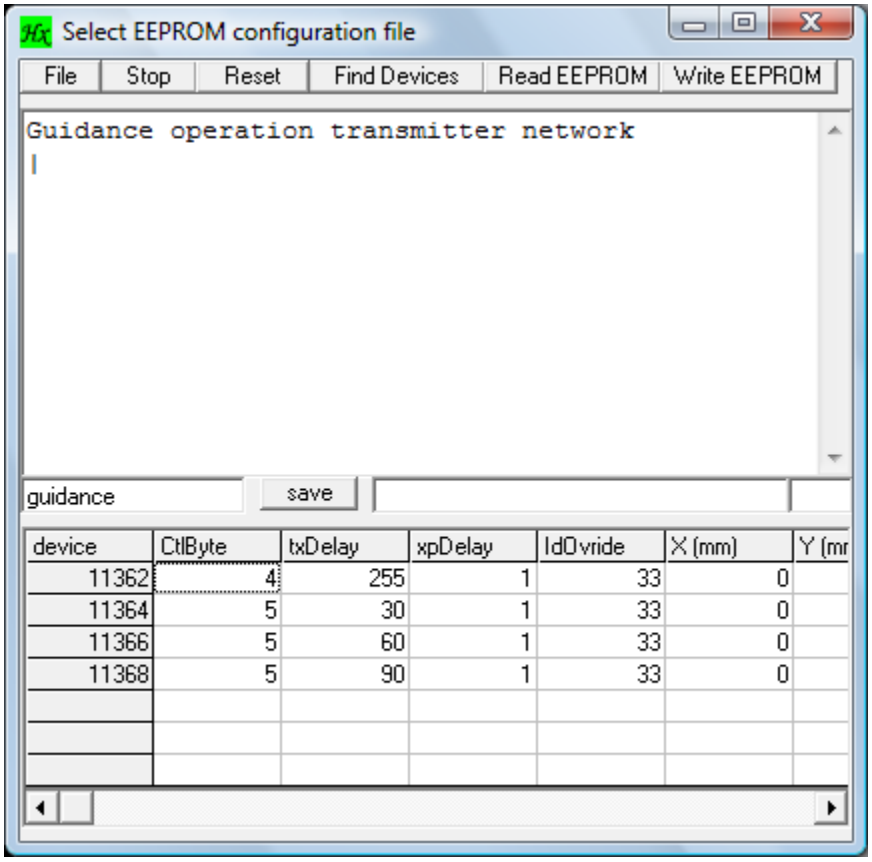
The following suggests some configuration parameters for the purpose of ultrasonic guidance operation as shown in the illustration above.

The configuration

Let devices A,B,C and D equal devices 11362, 11364, 11366 and 11368

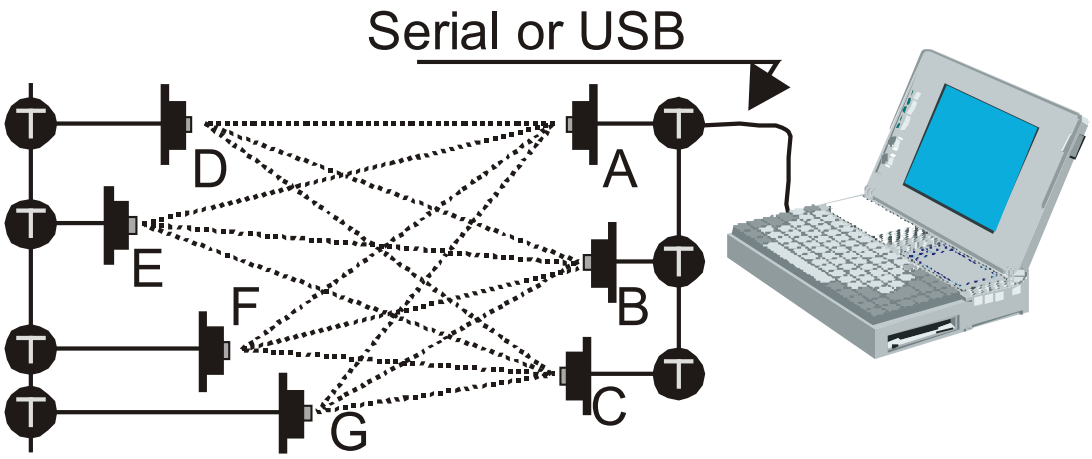
Guidance operation transmitter network.

```
|
11362          4              255            1              33
11364          5              30             1              33
11366          5              60             1              33
11368          5              90             1              33
```



Ultrasonic positioning and moving frames

The following illustration suggests a setup of moving frames, in case the receivers are mounted on an object, the orientation as well as the location with respect to the transmitters can be computed.



Given that A, B, C, D, E, F and G are devices 11362, 11364, 11366, 11368, 11370, 11372 and 11374.

Then the configuration file would look like the following.

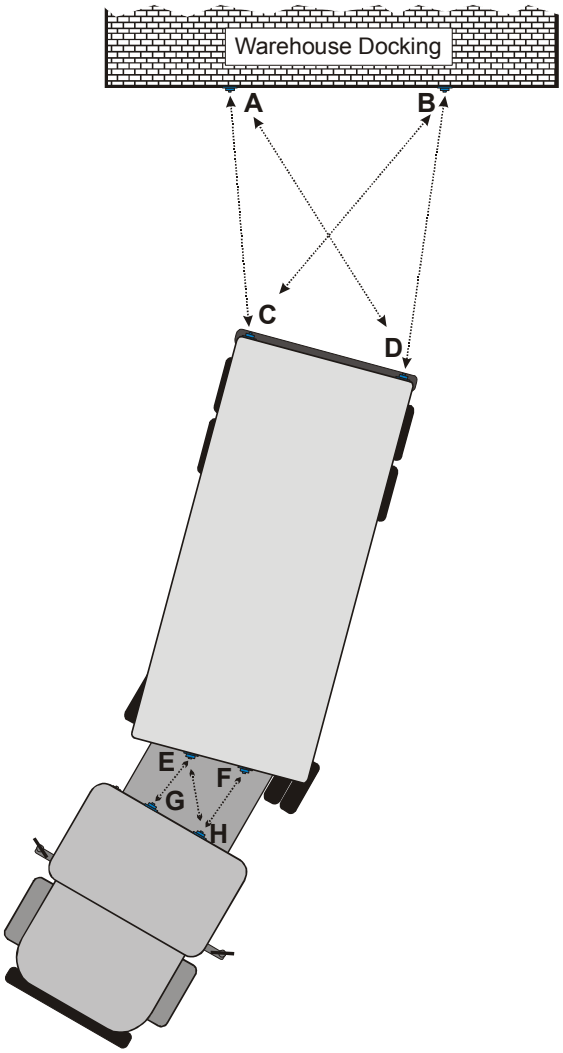
Guidance operation transmitter network, moving frames.

```
|
11362          4              255            1              33
11364          4              255            1              33
11366          4              255            1              33
11368          5               30            1              33
11370          5               60            1              33
11372          5               90            1              33
11374          5              120            1              33
```

The only limit to how many devices may be added to the network. Is determined by the number of device Ids available, approx. 30000 devices.

Ultrasonic Docking System

The image to the right suggests how the HX11TR can be used to guide a vehicle to a docking spot precisely. A computer may be placed inside the vehicle, and show dynamically the position of the truck and the trailer with respect to the target (from the top). There are a few ways to set up the HX11TR to serve for this application. One good way is to configure C and D as callers and configure A and B as transponders. Similarly E and F would be configured as transponders, and G and H configured as callers. Distances AC, AD, BC and BD will be available, and so will EG, EH, FG, and FH, with less than a centimeter precision. Audible signals can be used to guide the driver into a straight position with respect to the target as shown in the illustration below.



Let

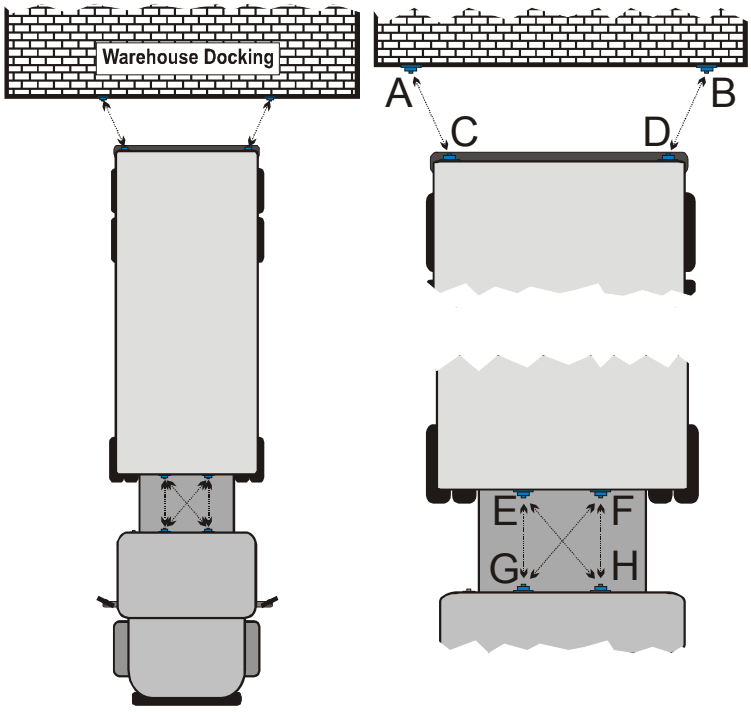
point A = HX11TR device 11362
point B = HX11TR device 11364
point C = HX11TR device 11366
point D = HX11TR device 11368
point E = HX11TR device 11370
point F = HX11TR device 11372
point G = HX11TR device 11374
point H = HX11TR device 11376

A configuration file for the Ultrasonic Docking System.

The configuration file below can be created using notepad or standard text editor, and the parameters down loaded into the EEPROM of the HX11TR devices. (See the configuration utility)

FILE: UDS.set (See configuration utility)

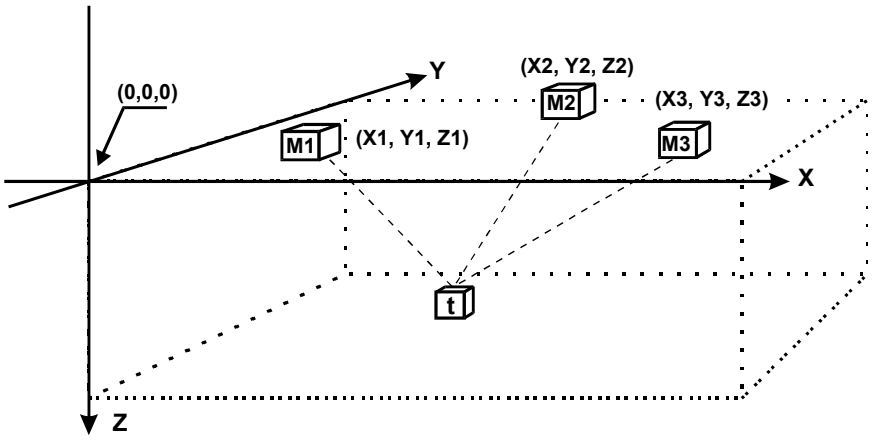
```
The following is an example setup file for the Ultrasonic Docking
System.
|
11362          0              255            0              33
11364          0              255            2              33
11366          5                1            1              15
11368          5               12            1              14
11370          0              255            0              33
11372          0              255            2              33
11374          5                1            1              13
11376          5               12            1              12
```



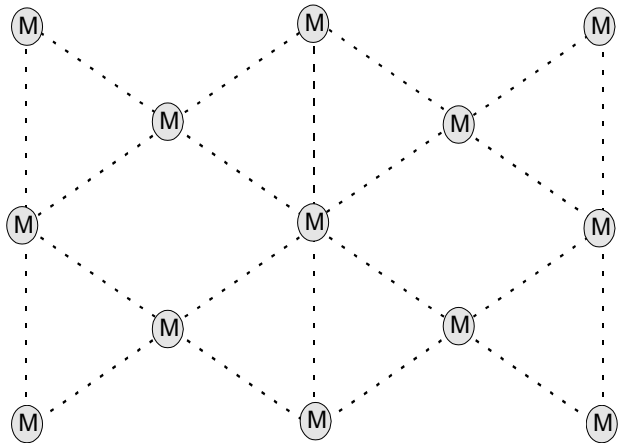
The objective is to get the vehicle in straight line with the target as shown above. Transponders A and B can also be mobile and placed on a tripod in appropriate positions to guide the driver.

3D ultrasonic tracking multiple transmitters

The illustration below shows a very basic tracking system, (battery powered) transmitter "t" is free moving and transmitting at preset intervals. The monitors will identify and enable positioning of up to 1000 different transmitters. Monitors located at known coordinates (X, Y, Z), store the time-tag from the transmitter in ring buffers. The monitors are all connected together on a network, and the network is connected to a controller synchronizing Hx11c. The controller transmits the synchronization signal, and polls the monitors for the contents of their ring buffers. The controller is connected to a serial or USB port of a computing device such as a PC. The PC converts the time difference data into real (X, Y, Z) coordinates. These coordinates are made available real time to other programs running on the computer via DDE or Dynamic Data Exchange. See the xyz program.



The monitor network is expandable to thousands of monitors to cover a wide area. It is at the user's discretion to set the network (positions of the monitors) up in an appropriate formation. Perhaps the simplest formation would be as shown below, where distances between monitors are everywhere the same.



The program HX11XYZ or the XYZ program needs the HX11C or the network controller to read the HX11TR (receiver) network, the time difference as measured by the network is used to compute the XYZ coordinates. The XYZ program can also read the information from the HX11C or through the datalog program, as the time of flight difference (time tags) gets stored on the disk through DDE. The XYZ program also makes the true 3D coordinates available through DDE.

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 on a disk as it becomes available. These programs need network connection, to a group of at least four HX11 monitors. For meaningful evaluation of the HX11 3D networked application a minimum of six Hx11 monitors should be used. To use the following programs, the hx11m must be connected to the computer through a network controller Hx11c

The following programs are written for the ultrasonic tracking of transmitters under a network of receivers. This network can contain anywhere from four to thirty thousand receiving monitors, and it can track up to a thousand transmitters.

```
Ultrasonic tracking asynchronized time difference application
|
11362          4              255            1              33
11364          4              255            1              33
11366          4              255            1              33
11368          4              255            1              33
11370          5               10            1              33
```

Devices 11362 to 11368 are all set up as non-transponding receivers. Device 11370 is configured as a transmitter repeating the transmission every 10 x 4.096 mS. **Default factory settings for the HX11M is 0 i.e. a transponding receiver.** A transponding receiver can be used for asynchronized time difference tracking, but is slightly slower in that mode.

The network can contain a high number of receivers, in which case the configuration file would look be along these lines:

```
Ultrasonic tracking asynchronized time difference application
|
11362          4              255            1              33
11364          4              255            1              33
11366          4              255            1              33
11368          4              255            1              33
      .
      .
      .
65534          4              255            1              33
```

See Hx11config.